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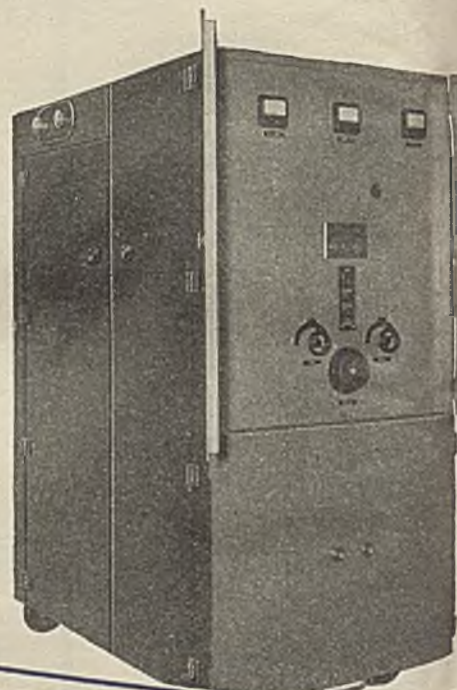

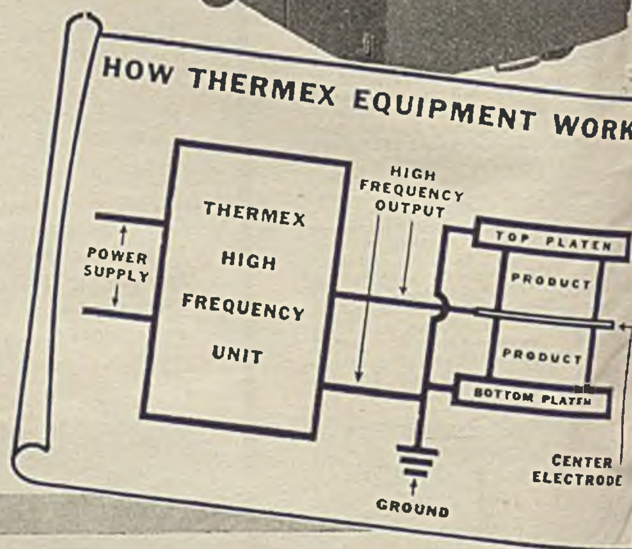

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ESTABLISHED 1902

MAY, 1943

S. D. KIRKPATRICK, *Editor*

THE TAX THAT KILLS

Congress has so completely sacrificed principle to political expediency in its various proposals for pay-as-you-go taxation on individual incomes, that we may well be apprehensive about those phases of the revenue program which will vitally affect our industries. There is altogether too little recognition of the simple fact that business cannot survive—let alone grow to provide future jobs—unless some part of its earnings can be plowed back into reserves for expansion and new enterprise. No one quarrels with the principle of the excess profits tax—especially in war times—but we must make certain that its continued practice is soundly in line with theory. Especially in chemical industry is it important that we have left some "seed money" with which to grow a new crop of peace-time products.

More and more companies are beginning to ask where the money is going to come from to finance the conversion of their plants to meet postwar demands. The present system of taxation has not permitted them to build up adequate reserves to purchase new equipment or revamp existing facilities. Even some of the firms that have accepted recapture clauses in their contracts with the Defense Plant Corporation are beginning to realize now that they may not be able financially to acquire the properties they have built and are now operating for the government. The only alternative is to look for outside capital but this adds uncertainty and delay to other equally disturbing problems. Always, too, there is the threat of governmental operation—even nationalization of industry—in the event that private enterprise is not ready to go ahead when the time comes.

Next in importance to postwar conversion of facilities is the current need for more "seed money" to pay for the research work that must be done before new products can be developed. As noted in these columns last month, we have already seen the tax administration authorities rule against certain apparently logical charges for increased investigational work by chemical companies which are already engaged in extensive research. If such arbitrary and dangerous rulings are written into our new tax law, we will sorely penalize, if not vitiate, technical progress in some of the industries that are now most conscious of their opportunities and obligations for providing future jobs.

Nor must we permit the glamour of new product development to blind us to the fact that money will also be needed soon to rebuild and revamp our distribution machinery. Unfortunately, this part of the industrial organization has been hit hardest by the war. Yet in industries where engineering services are essential to sales, particularly of new materials and products, management cannot afford to overlook the need for larger investments in distribution.

These and other equally necessitous considerations will be a part of the new tax law, provided Congress is willing to give something more than lip service to the guiding principles of the private enterprise system. There must be recognition of reward as the primary incentive for stimulating people to work for themselves and to provide work for others. If we are true Americans we are more interested in "opportunity" than in "security." The former is positive and creative for it means multiplication of our wealth and resources. The latter is negative and destructive for it means but division and decay of wealth already created.

How about letting your Congressman know whether or not "seed money" is important to the future of your family, company and community?

MAKING RUBBER THE GOAT

Again Washington is wrangling over shortages of chemical engineering equipment. More of these scarce facilities are needed for high-octane gasoline, for synthetic rubber, and for special small naval fighting ships than the fabricating units of the country can immediately assemble. As a consequence, there has been some disposition by military authorities to blame the rubber program for shortages of aviation gasoline.

It seems wholly unnecessary that the officers of our military departments should thus seek an alibi for their own mistakes in judgment or timing. No one really criticizes them for having under-estimated the military needs. Indeed it would have been surprising if they had adequately foreseen the tremendous increase in air combat and the corresponding need for high-octane fuel.

It does seem logical at least mildly to censure these officials when they try to demonstrate that someone else is taking away from them the facilities that would have corrected their inadequate estimates. They put themselves in a very dangerous position before the public when their charges are disproved, even by the explanations of a friendly Secretary of the Interior.

It is unfortunate, of course, that we cannot make equipment as fast as we want it. But quarrelling about who is to blame will not make for fair allocations of the limited number of high-pressure units that are available. Cooperation in a vigorous prosecution of all programs will bring us closer to sound over-all military results. •

PATENTS FOR PUBLIC USE

Both Standard Oil of New Jersey and Firestone Tire and Rubber have offered to transfer to the government the ownership and control of certain important synthetic rubber patents. This is convincing evidence of the known desires of these industries to make synthetic rubber a commercial success in the United States without regard to private rights or the interests of individual corporations.

Perhaps no other action that could be taken would so completely demonstrate the sincerity with which great industrial managements have viewed their public responsibility in corporate enterprise. It is fortunate indeed that the unfair, often unscrupulous, attacks on the officials of Standard Oil should not have destroyed the spirit of public service which is here shown. If it were possible to tell the full story of self-sacrifice of that company and others in the immediate pre-war period, the public would feel very differently toward these units of "big business."

Some day the story will be told. Then, we confidently believe, the public will be much less sympathetic with some of the carping critics in high official positions.

MORE SAFETY ENGINEERS FOR INDUSTRY

Training for safety in industry is always important. During a war period steps for the conservation of manpower and protection of equipment are more than usually important. For this reason the Division of Labor Standards and the U. S. Office of Education are collaborating to utilize the engineering training facilities of the latter agency for courses in "safety engineering." Large numbers of operating foremen and professional engineers are being given short courses to facilitate on-the-job instruction in safety for millions of workers. The benefit to both privately owned and government-owned industry is bound to be considerable.

Postwar planning for similar training of young engineers is contemplated. Steps are being taken to make possible better facilities and staffs in the engineering colleges in order to give such work to many young men seeking their bachelor degrees in the different divisions of engineering.

Industrial executives and college faculties will welcome this effort. By the cooperation of two such practical groups it should be possible to place the safety features of engineering training very effectively into their proper place in the college curricula. It is a big job, but it is worth all the effort which it will take to carry it through.

WASHINGTON HIGHLIGHTS

PEAK OUTPUT of chemicals is still ahead. The fact that the government has temporarily closed down certain ordnance plants, notably those making explosives and explosive raw materials, cannot rightly be understood to mean that the peak of war demand has passed. The shutdowns are the result of unbalanced production, the inevitable consequence of the rapid multiplication of demands without any available basis for accurate forecast as to one commodity in relation to all others. But it is still unsafe to conclude that many major chemicals will soon be found in surplus. Peak manufacture by industry as a whole is not expected until late this year.

FERTILIZERS must be promoted to become feeds, and feeds must become foods to the maximum possible extent. This is necessary in order that the maximum food supply be arranged for the United States and its allies. Among other things is the necessity of converting many oilseed meals to food uses. This requires improved chemical engineering practice during seed crushing so that the press cake will be of food grade. And there are dozens of other possible services of great importance calling for engineering attention.

BETTER FUEL and energy supplies, as proposed by the Bureau of Mines, would be very welcome and useful if they did not require so much new equipment. It would be more useful, we believe, if industry as well as the Bureau, would get out of their old files all usable ideas for stretching existing fuel supplies to the very maximum. Among such improvements is the making of oil and coal mixtures which may stretch limited fuel supplies to greater industrial service for process and boiler purposes.

DAVIS' APPOINTMENT has met with favorable reception in industrial as well as farm circles. He is a man of marked ability and experience, with an intimate knowledge of the economics and technology of many process industries.

Chem & Met reports on ..

Measurement and Control of Process Variables

While the unit operations and unit processes are generally thought of as being the least common denominators of the process industries, process control is equally as all-pervasive. In fact, process control is often classed as a unit operation, and a most important one, for without reliable control methods, manual or automatic, process industries could not operate. Automatic control is one of the cornerstones of continuous processes and the development of such processes and such control has largely gone hand in hand. An even greater degree of progress could have been made if this principle had been even more thoroughly recognized. For in that case, fewer processes would have been developed with the idea of fitting the control as an after-thought.

FOURTEEN years ago when *Chem. & Met.* brought out its first Process Control issue, what is now the science of automatic control was largely an art. The first book on the art, other than pamphlets and manufacturers' literature, was still to be published in the United States. The first magazine devoted to the subject had just begun publication the year before. Industrial instruments, by comparison with those of today, were relatively crude and not very versatile, but it is significant that instrument design was considerably ahead of the science. Many were the queer contraptions rigged up in the name of automatic control, but it should be realized that even then, the important control effects used today were recognized by some engineers, and means had been developed, crude to be sure, for achieving them.

A much different situation obtains today. Tremendous progress has been made in design and special effects that were then available only to the ingenious few on the basis of their own home-made designs are now regularly obtainable from several manufacturers. Even greater progress has been made, proportionately, in the development of understanding of the science. To some extent it is still probably true that design is leading the science, but the science has been catching up, and the acceleration resulting from the war may be expected to make the current period an even more productive one than any of equal time that has passed. Important advances are in the offing.

As the art and the science have been growing since the first Process Control issue, so has the literature. Other means of disseminating information have become equally important, such as the Industrial Instruments and Regulators division of A.S.M.E., the numerous local control organizations that have flourished, and the courses on industrial instrumentation that have been instituted in technical schools.

In approaching a subject now so thoroughly treated in the deliberations of societies and in the literature, *Chem. & Met.* was faced with many serious problems in the choice of the most suitable type of material for its particular class of readers. Whether this choice was well made the future will demonstrate. In any event, the decision was made to attempt a clarification of automatic control theory for user, rather than for instrument manufacturer engineers; to review as many as possible of the process variables ordinarily encountered and to show the principal means for measuring and controlling each one; to look into the future of industrial instruments; and to examine a number of special aspects such as controllability in relation to process design, and the effect of valve characteristics on control.

To all those control engineers who sat in conferences with *Chem. & Met.* editors to discuss and formulate this editorial program we extend our thanks, and particularly to those who gave their time as well for the preparation of manuscripts. On the basis these engineers are operating, this time represented a real sacrifice, for them and for their companies.

Fundamental Principles of Automatic Control

J. C. PETERS and THEODORE R. OLIVE

Respectively, Chief, Automatic Control Div., Research Dept., Leeds & Northrup Co., Philadelphia, Pa., and Associate Editor, Chemical & Metallurgical Engineering, New York

To those people who are not thoroughly familiar with automatic control the science has an aura of mystery which does not rightfully belong to it. While it is possible to get into extremely complex situations, the fundamentals can be approached non-mathematically, which is the type of approach used in this review.—*Editors.*

Automatic control has become an integral part of industrial process work, especially since so many processes have been put on a continuous basis. In fact, it may be stated with few exceptions that continuous processes would be impossible without automatic control. Control of batch processes is usually quite simple and can often be accomplished either through manual control by an operator, or by an automatic controller of a relatively elementary type. With continuity of processing, however, the problem of maintaining optimum conditions within a continuously flowing mass of material usually becomes sufficiently complex to make automatic control essential. Such a process generally requires the use of one or more controllers of a more or less highly developed type.

Basically, the fundamentals of automatic control are not particularly complex, although two groups of factors have tended to make the subject seem so. On the one hand, there is the vast array of mechanisms which have been developed for carrying out various kinds of control, often with the appearance of having little in common with each other. And on the other hand, there is the equally enormous terminology which has developed among various workers in the field, often with as many as half a dozen different expressions used to describe a single idea.

PROBLEM OF LANGUAGE

The first problem has to some extent been mitigated in recent years by a developing tendency to eliminate some of the more poorly defined mechanisms, as well as some of the cross-breeds, and to standardize on a relatively few types of controller which accomplish the several different kinds of control in readily recognizable ways. The second problem, that of language, is unfortunately still far from stabilized in spite of many efforts that have been made to develop terms which will be acceptable to everyone. A few terms are now generally employed. Where others must be used, only recourse to careful definition can avoid the possibilities of misunderstanding.

CONTROL NOT MYSTERIOUS

Still a third problem, which has tended to throw a veil of mystery over the subject for those having only a partial acquaintance with it, is the complex character of the actual mathematical relations that may be involved. The situation is not dissimilar to that of astronomy, or the motion of the tides. Everyone understands in a descriptive way the motion of the heavenly bodies and the rise and fall of the tides, and yet the actual prediction of future positions is of extreme mathematical complexity.

Astronomical mathematics, however, is a science which has developed over the centuries, whereas the quantitative study of processes and their control is recent. It is not surprising, therefore, that many problems have not as yet yielded to exact quantitative analysis. Nor is such an analysis necessary before the new science of automatic control can be used. A general understanding of the laws governing processes and their control need not await an exact expression of the laws. The theory can be formulated without a knowledge of the actual coefficients that may be encountered, and can usually serve as a reliable guide to successful experimental approach to problems in automatic control, and to the achievement of suitable adjustments for controllers.

In essence, the control of a continuous process is the act of maintaining within limits (or altering in a predetermined manner) the energy and sometimes material balances in a continuous flow of matter which is undergoing treatment. A continuous process may be defined as any process in which a continuous flow of one or more materials is undergoing chemical or physical change for the purpose of producing a desired final result or change in the material. Automatic control of such a process is the use of automatic mechanisms to maintain significant process variables (or vary them as desired).

An automatic controller is a device which will measure the state of a particular process variable, either continuously or at frequent intervals, and then make any corrections in the flow of either materials or energy that may be required to maintain the value of the variable within acceptable limits. A process variable is any manifestation of the process or material which may vary with time. Familiar examples of process variables include physical conditions such as temperature, pressure, level, flow rate, amount, velocity, speed and the electrical quantities. Among the variable properties of chemicals are composition, humidity, density and specific gravity, electrical conductivity, hydrogen ion concentration, viscosity, color and opacity, refractivity, dielectric constant and magnetic susceptibility.

INDEPENDENT VARIABLES

Generally a process contains a number of variables which can be independently controlled, and others which are dependent on these. For example, the pressure of saturated steam is determined by its temperature. Similarly, the density, pH and viscosity of a liquid are determined by its temperature and composition.

The first problem in controlling any process is to isolate significant independent variables and then make certain that each is controlled. However, it is not always necessary to measure an independent variable directly for this purpose. Some other property more readily measured or more convenient as an index of the independent condition may be chosen. Humidity, for example, may be measured and controlled from measurements made with wet- and dry-bulb thermometers (psychrometers).

If the temperature is controlled or compensated for, measurement of pH can often be used in the control of composition. Measurement of its dielectric constant can be used in measuring and controlling the moisture content of a moving web of paper.

Any automatic controller necessarily consists of two essential parts, a measuring part and a controlling part. In many controllers these parts are further subdivided and four fundamental elements are recognized: (1) a primary sensitive element, such as a thermometer bulb or pH electrode, subjected to the instantaneous condition of the process variable being controlled; (2) a measuring element which converts the response of the primary sensitive element into some sort of indication of the state of the variable —perhaps by positioning a pointer on a scale, or sometimes, non-visually, by adjusting the relative position of the parts of the controller; (3) the controller proper, which detects any deviation of the instantaneous position of the measuring element from a desired control point, and initiates appropriate corrective action, and (4) a final control element which is adjusted by suitable positioning means in accordance with corrective impulses from the controller proper, so as to vary the flow of process energy or material as required to return the measured variable to the control point.

SIMPLE CONTROLLERS

In some controllers all four elements are not separate and distinct. For example, in a self-operating temperature controller, element (1) may be a thermometer bulb, which contains a low-boiling liquid having relatively high vapor pressure at the desired control temperature. This bulb is connected by means of capillary tubing to a bellows which responds to the vapor pressure of the liquid in the thermometer bulb by expanding or contracting, thus fulfilling the function of element (2) and measuring the temperature of the bulb. However, the bellows also acts as element (3) in that it is directly connected to and positions the final control element, the valve. This last, element (4), then regulates the flow of heating fluid to the process, adjusting this flow in the case of a deviation so as to direct the temperature toward the control point.

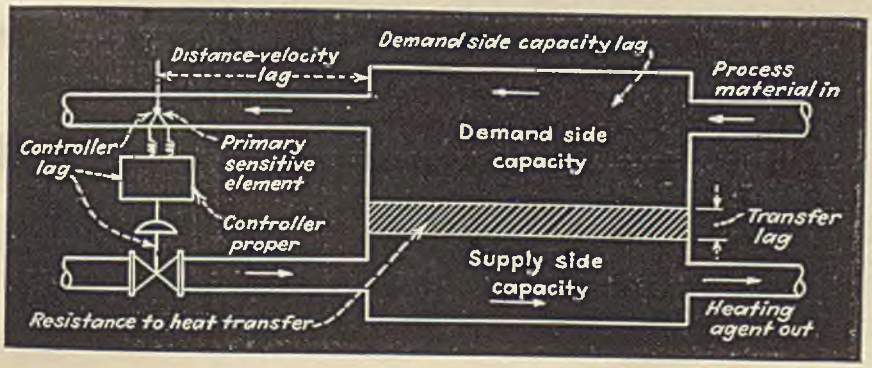
Another simple case where two elements are combined is the ordinary bimetallic thermostat, as used to control air temperature. Here a bimetallic strip subjected to the temperature of the air, serves as element (1), and by the position of its free end indicates the air temperature, thus acting as element (2). If the temperature is below the control point, the position of the strip closes an electrical contact, element (3), thus energizing a resistance heater directly or positioning a final element (4) which may be an electrical relay, rheostat, fuel valve or other means of varying heat flow.

Still a third case is a liquid level controller in which a float is directly connected to the supply valve. Here the float detects the level, thus acting as element (1). By its vertical position it indicates the level and it is thus seen to serve as element (2). But at the same time, it directly positions the supply valve and hence acts as element (3). The valve itself, of course, is element (4).

Many controllers, however, show all four elements. In a pH controller, for example, the two electrodes generate a potential related to the pH of the surrounding liquid, serving as element (1). This potential is then measured by a self-balancing potentiometer, element (2), and any deviation of the measurement from the control point initiates a control response through element (3), which may be either a pneumatic or electrical system, so as to adjust a valve, element (4), which controls the flow of one of the materials entering the reaction system.

Similarly, in most temperature control problems a sensitive element such as a thermocouple or a thermometer bulb (1), produces a response related to the temperature, actuating a measuring element such as a potentiometer or pressure spring (2), which measures the temperature of the sensitive element. A control system (3) then detects any deviation from the control point and in turn adjusts a final control element (4), such as a valve, to direct the temperature toward the control point.

Fig. 1—Simple heat exchanger example showing the various lags which may be encountered in a temperature control problem



Fundamentally, all automatic control problems are largely similar, regardless of the particular process variable which is being controlled. Therefore, in discussing control, it can to a considerable extent be viewed apart from the actual variable except that to consider it with a particular variable aids visualization of the problems involved, especially the complicating factors such as lags and capacities which take the average control applicatino out of the range of the very simple. Consequently, various investigators in the control field have chosen variables which they prefer to study, either temperature, liquid level, gas pressure, or electrical energy, and have studied the desired relations of the one variable, extending the results to others by analogy.

THERMAL SYSTEMS

A thermal system has a number of advantages compared with the others mentioned, both for study and for explanation. In the first place, the great majority of all automatic control systems are for temperature. And secondly, the question of lags and capacities is more easily visualized with a thermal system than with some of the others. Except where pertinent comparisons are desirable, therefore, this article will confine itself to temperature control, with the understanding that the principles derived can be extended by analogy to other systems where they are applicable.

The problem of temperature control in a continuous process is one of matching the rate of heat supply to the rate of heat demand, in the face of a variety of complicating factors. It is thus a problem in suitably regulating the rate of heat transfer. Perhaps the simplest way of analyzing the complications of a temperature control application is to set up a simple process as if it were a heat exchanger, as in Fig 1, which is similar to the approach used by Haigler (A.S.M.E., *Trans.*, Nov. 1938, pp. 633-640).

The heat requirements of material being processed in Fig. 1 constitute the demand, while the heat available in the heating agent represents the supply. Numerous factors can upset the desired balance of energy in the process. On the supply side, for example, the pressure of the heating steam may change, or the voltage of electrical energy used for heating. On the demand side, the flow of process material may increase or decrease; its entering temperature may change; radiation to the surroundings may change due to a change in ambient temperature; or a reaction which is taking place in the process may become more or less exothermic or endothermic.

Furthermore, there are still other factors which can affect the rate of heat transfer without a change in demand. Except where the heating is the result of direct contact with the hot substance, or with radiation from it, heat must pass through a barrier separating the demand and supply sides. The thermal resistance of this heat transfer barrier will determine the temperature potential necessary to force a given quantity of heat through a unit area of the barrier in a given time. Hence, changes in the character of the surface, as by scaling or corrosion, can affect the thermal head necessary, while in the case of a vertical barrier, changes in level on either the supply or demand sides will affect the area available for heat transfer.

Thus it is clear that it must be possible to detect any unbalance between heat demand and supply, as evidenced by a change in the temperature of the effluent stream, and then to alter the thermal potential in such a way that the new required rate of heat transfer will be obtained promptly and without serious "overshooting." In the case of the ideal process, this is a simple matter. Unfortunately, inherent in most processes are unfavorable "lags" which on the one hand delay the discovery of a disturbance, and retard the recognition of its magnitude, and on the other hand retard the establishment of a new thermal potential. Further, controllers themselves require more or less time to detect changes and make the necessary corrections, giving rise to the "controller lags."

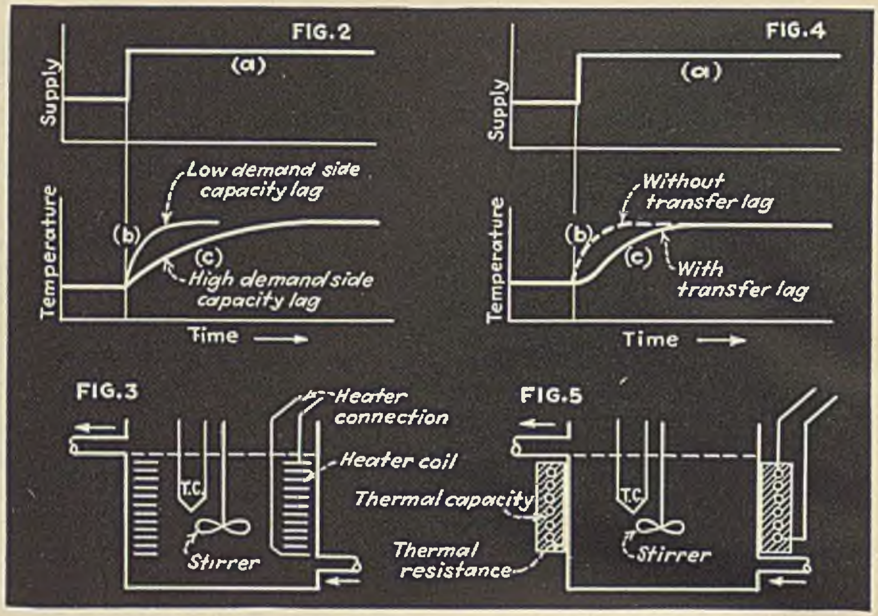


Fig. 2—Temperature response to change in supply, of an uncontrolled process having only demand side capacity lay

Fig. 3—Electrically heated vessel having substantially only demand side capacity lag (see Fig. 2)

Fig. 4—Temperature response, to change in supply, of an uncontrolled system having both demand side capacity lag and transfer lag

Fig. 5—Electrically heated vessel having thermal resistance and thermal capacity (transfer lag), as well as demand side capacity lag (see Fig. 4)

PROCESS LAGS

The first process lag to be considered is not ordinarily disadvantageous to control. In fact, it is usually an advantage. Referring to Fig. 1, this is the demand side capacity lag, which results from the heat storage and consequent "thermal inertia" of the demand side. A high demand side capacity tends to stabilize the process temperature and prevent rapid departures from the control point. It is disadvantageous only when prompt response to a change in control point is desired. Fig. 2 portrays the situation in an uncontrolled process, with demand side capacity lag only, when a sudden supply change takes place. Curve (*a*) shows the change in supply, while curves (*b*) and (*c*) show the resulting change in temperature. A process with low demand side capacity becomes stabilized quickly at the new temperature as in (*b*), while one with high demand side capacity responds slowly as in (*c*). At a given rate of outflow a receiver containing a large volume of process material thus tends to be more stable than one containing a small volume of material. A jacketed vessel, for example, is more stable than a shell-and-tube heat exchanger, which in turn is more stable than a concentric pipe heater.

Actually the rate of response is dependent upon both the volume or energy storage capacity of a receiver and the rate of flow of material or energy through it. The rate of response is the same for all cases in which the ratio of these factors is the same.

Although it is true that high demand side capacity is usually a favorable factor in control, this presupposes the ability to attain uniform conditions rapidly throughout the bulk of the material, as by thorough mixing.

It may assist in visualizing demand side capacity lag to examine a vessel in which that lag is substantially the only one present. Fig. 3 shows a continuous water heater in which an electric heating element is immersed. The element is an edge-wound strip of large surface and small cross sectional area. A stirrer quickly brings all of the water to uniform temperature, while the heating surface is so large and the stirring so effective that there is little thermal resistance between the heater and the water and both are at substantially the same temperature. Therefore, a rapid-acting thermocouple will almost immediately detect a change in power supplied to the heater, or a change in water flow rate, by a change in water temperature. Still, owing to the heat capacity of the water in the vessel, the temperature of the out-flowing water cannot change rapidly in case of an unbalance between supply and demand, and the temperature curve might be similar to that of Fig. 2 (*c*).

TRANSFER LAG

Where the thermal inertia of the demand side is ordinarily favorable, the reverse is true of the supply side capacity and its thermal inertia. The supply side capacity can be considered the sum of all conditions on the heat supply side which tend to stabilize the available rate of heat transfer and make a change to a higher or lower heat transfer rate either difficult or time consuming. For example, time is required to change the temperature of the heating medium. Furthermore, any barrier between supply and demand sides adds thermal capacity as well as thermal resistance and if its capacity is high, acts as a thermal flywheel which must itself gain or lose considerable energy before a new desired rate of heat transfer can be achieved. Still another example is a fuel-fired furnace with refractory walls. The heat capacity of such furnace walls is another thermal flywheel, which is one of the important reasons for the use of water-cooled walls in modern high-steaming boilers which must be subject to close and rapid control.

Thus supply side capacity and the thermal resistance of a heat transfer barrier result in another lag, known as transfer lag, which is the retardation in establishing a new heat transfer rate following a change in supply potential. The curves of Fig. 4 portray the situation in an uncontrolled process having both demand side capacity lag and transfer lag. Curve (*a*) shows the change in supply, (*b*) the response to a supply change with demand side capacity lag only, and (*c*) the response when both lags are present.

Transfer lag, as defined above, is always unfavorable to control since it limits the rate at which a change in supply rate can be made effective on the demand side. The result, of course, is a tendency to cause overshooting in a controlled process.

CAPACITY AND RESISTANCE

It will be helpful in visualizing transfer lag to examine a process vessel in which this lag is present to a considerable degree. The vessel of Fig. 5 introduces both supply side capacity and transfer lag in addition to the demand side capacity inherent in a considerable body of liquid. The heating element in this case is outside the vessel and embedded in a ceramic of high heat capacity. It is instructive to consider the ceramic as composed of two parts, the shaded part which is of high heat capacity and negligible thermal resistance, and the solid portion which is of negligible heat capacity and high thermal resistance. As long as conditions in the system are steady and heat supply and demand are in balance, the rate of heat transfer to the water will depend only on the temperature drop across the solid portion of the ceramic, which has thermal resistance. The thermal capacity of the shaded portion then has no effect. The heater temperature may either be close to that of the bath, or much above it, depending on the magnitude of the thermal resistance of the ceramic.

When a demand change occurs, however, the thermal capacity of the shaded area comes into play. A new rate of energy supply can be established instantly in the heater winding, but time is required to change the temperature of the shaded ceramic, owing to its heat capacity. The higher the resistance, the greater the thermal head required, and the higher the capacity of the supply side, the longer will be the time required to build up the necessary thermal head which will produce the new heat transfer rate.

The third type of process lag is usually called distance-velocity lag, because it is a delay (not a retardation) representing the time required to transport a material over a given distance at a given velocity. Its relation to the other lags is indicated in Fig. 1. This lag occurs, for example, where the sensitive element is located in the effluent pipe at some distance from a reaction vessel. It is directly proportional to the distance and inversely proportional to the velocity of flow through the effluent pipe and hence has the units of time.

The sketch of Fig. 6 shows an idealized process which can either be substantially free from all process lags, or can contain practically pure distance-velocity lag, depending on the location of the sensitive element. Here a flow of cold fluid passes through some sort of rapid and efficient mixing device such as a venturi tube, the hot fluid being introduced through openings at the throat. When the temperature sensitive element is situated at (*a*) which is as close to the mixing point as it can be, and still assure completeness of mixing, the process has no appreciable lags.

If it were possible to employ a rapid enough controller so that the instrument lag was substantially eliminated, then with the sensitive element at position (*a*), the process would operate without deviation from the control point except for one factor. Some deviation, however small, is necessary to cause a control action.

If the sensitive element is moved from the point of mixing, as to (*b*), distance-velocity lag is introduced. In this case, even with an ideal controller having no lags, any change in demand which takes place during the time required for the liquid to travel from (*a*) to (*b*) will have its full effect on the temperature. Satisfactory control is frequently obtained in spite of distance-velocity lag by introducing sufficient demand side capacity. The result is to reduce the rate at which the controlled variable can change after a change in demand. A suitable value of demand side capacity can usually be arrived at by taking into account the largest unbalance between supply and demand likely to be encountered, the maximum permissible deviation, and the distance-velocity lag.

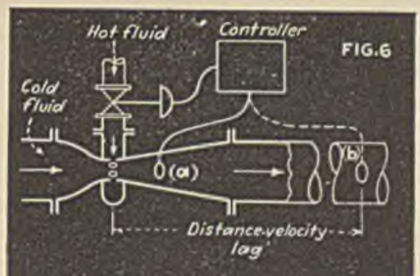
REACTION LAG

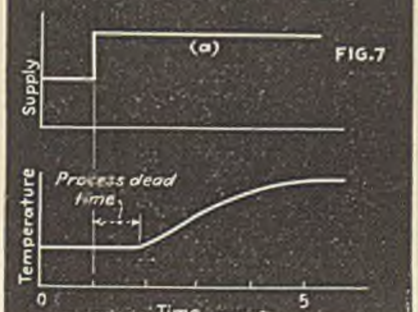
Still one more type of process lag is sometimes encountered, not in temperature control, but rather in the control of chemical reactions, as by the measurement of some property of the composition of the reaction product, such as the pH of a solution. Many reactions take a considerable time to reach a new equilibrium after the mixing of the reactants and it is impossible during this time for the controller to know the results of the mixing. If then an effort is made to control the pH after the reaction is complete, by installing the electrodes in the effluent line at a distance from the mixing tank, distance-velocity lag is introduced and must be dealt with.

The total result of the various process lags discussed above may be, in an unfavorable case, the production of a record of process response which for a considerable time will give little or no evidence of the supply change which produced it. Fig. 7, for example, shows a temperature response in an uncontrolled process influenced by demand side capacity, transfer and distance-velocity lag. In this curve no observable change occurs at first, after which a slow rate-of-change, followed by a maximum rate-of-change takes place. The period in which a change

Fig. 6—Idealized heating process having no lag if bulb is at (a), or distance-velocity lag only, if bulb is at (b)

Fig. 7—Temperature response, following a change in demand, of an uncontrolled process having distance-velocity lag, as well as transfer lag and demand side capacity lag





cannot be ascertained is usually called the process dead time. Obviously, the deviation cannot possibly be checked for a period equal to the dead time, even though a correction is made the instant the temperature begins to deviate from normal.

CONTROLLER LAG

One more lag, which pertains to the controller rather than to the process, must also be recognized. This lag is actually the resultant of a group of lags, some of which are retardations and some actual delays. Collectively, they may be referred to as controller lag (Fig. 1). The first manifestation of this lag is the time which may be required for the primary sensitive element to achieve equilibrium with the new temperature after a process disturbance. With a heavy thermometer bulb or a thermocouple in a heavy protecting tube, this lag may be considerable, while with an unprotected thermocouple or resistance thermometer of low heat capacity, it may be quite negligible.

The second factor in instrument lag is the time required for the measuring element to stabilize at the new indication. In some types of instrument this is rapid, in others fairly slow. The third factor is the time interval required while the controller element itself is detecting the deviation and issuing the proper correction response, while the fourth is the time necessary for the valve or other final control element to reach the final setting required by the controller.

The actual magnitudes of controller lags are of no significance except when considered in relation to response rates called for by changes in the process. These lags may or may not have appreciable effect with a particular mechanism, depending on the application. In some cases the lags of the controller predominate, usually because of the nature of the required measuring mechanism, and a relatively refined form of controller must be used to overcome the effects of its own lags.

SELF-REGULATION

An important characteristic of processes which bears on the ease with which they may be controlled is their degree of tendency toward self-regulation. The situation is comparable to the matter of equilibrium in mechanics. (1) A boat, for example, is self-balancing, reaching a new stable equilibrium whenever its center of gravity is shifted within the limits of stability. (2) A block resting on a table remains in equilibrium no matter how it is moved. (3) A pencil balanced on its point is in unstable equilibrium, the slightest disturbance sending it over.

The first case is an example of self-regulation, and has many counterparts in control. In a continuous liquid heater, for example, an increase in heat supply will cause more heat to be carried from the heater in the effluent stream, thus tending partially to offset the unbalance. A perfect case of self-regulation is an open tank out of which water flows by gravity through an orifice. As long as the head required does not exceed the height of the tank, every rate of inflow will produce a head in the tank just sufficient to give an outflow equal to the inflow.

The second case is that of processes which tend neither to balance nor to become further unbalanced following a change in demand. An example is the tank of the previous illustration when water is removed by a constant displacement pump operated at constant speed. Any sustained unbalance between inflow and outflow will then result in the vessel flooding or running dry.

The third case, that of unstable equilibrium, is often encountered in exothermic chemical reactions. In the nitration of glycerin, for example, the increase in reaction speed will assume explosive proportions and the reaction will run away if the temperature is allowed to go too high.

CONTROLLER RESPONSES

It is the problem of a controller to measure changes in the controlled condition, and to make corrections based on the measurements which will return the condition of the variable as quickly as possible toward the control point. In the simpler processes which have little lag aside from demand side capacity lag, the control problem is easy and a simple controller will do an excellent job. When such lags as transfer lag and distance-velocity lag are involved to an appreciable extent, a more complicated control mechanism is necessary. The more refined types of controller initiate corrective actions in accordance with the sense and amount of the deviation, the rate of change of the deviation and sometimes also the rate of change of the rate of change of the deviation. Although it is possible to analyze the various known controller response characteristics mathematically, the simplest approach is to do so graphically, as is done below.

In the analyses which follow, the process is assumed to be initially in equilibrium between demand and supply, after which a sudden demand change takes place.

The methods of control most generally used today may roughly be classified into (1) those types which provide one or more definite rates of flow of the supply medium; and (2) those types which provide a continuous range of flow rates of the supply medium, a suitable rate being selected by the controller in some predetermined relation to the deviation or rate of change of the deviation from the control point.

These types may be further classified as:

Two-position
Proportional-position
Floating
  (a) Single-speed-floating
  (b) Two-speed-floating
  (c) Proportional-speed-floating
Proportional-plus-floating (reset)
Proportional-plus-floating-plus-second derivative.

TWO-POSITION CONTROL

The first type of controller tabulated above, the two-position controller, is one in which the valve is adjusted to take either of two positions, a high value greater than the maximum demand, or a low value less than the minimum demand. It includes as a special case on-and-off controllers in which the control valve is either wide open or tight shut. Another special case is the multi-position type of controller in which the controller may select, say, a "low" high or a "high" high rate of supply flow if the deviation is slightly low, or considerably low; or a "high" low or a "low" low if the reverse conditions maintain.

The two-position controller is simple and cheap and gives excellent results in many processes having a fairly large demand side capacity lag, but no other lags of importance. A common type is the contact-making thermometer or pyrometer which opens a solenoid fuel valve to a suitable upper limit whenever the temperature is below the control point, de-energizing the valve and allowing it to close to a suitable lower limit whenever the temperature rises above the control point. To avoid too frequent valve changes in a responsive process, such controllers employ either high and low contacts to give a dead zone of suitable width, or a "differential" arrangement for operating the switch.

In Fig. 8 are charted the characteristic responses of a two-position controller before and after a change in load. Before discussing these curves it is in order to say that the controller is to be considered as applied to a process with the general characteristics of that of Fig. 5, discussed in the section on process lags. The controller is confronted by considerable transfer lag. A demand change is considered to be the ultimate change in heat requirement corresponding to a sudden change in the rate of flow of water through the tank. The supply is considered as the output of the heater. These assumptions apply not only to Fig. 8, but to all similar analyses that follow.

Referring now to Fig. 8, curve (*a*) shows the demand, (*b*) the temperature, and (*c*) the supply or valve position. Because of the transfer lag the controlled temperature continues to fall after the heater is energized on a down-swing; and continues to rise after it is de-energized on an up-swing. If the transfer lag were less, the swings would also be less. With demand side capacity lag only the direction of the temperature trend would instantly respond to change in rate of heating and there would be no overshooting.

In the earlier part of the record the temperature swings equally above the high and below the low limits of the dead zone. This is because the heat requirement is such that it is satisfied by the application of heat at the high rate 50 percent of the time, and at the low rate the remaining 50 percent of the time. In the middle portion of the record range, demand increases. This means that the higher supply rate will now be closer to the new demand, while the lower supply rate will be further removed. After a transient over-swing, therefore, the controller settles down to the new demand with its swing only slightly above the high control range limit, but considerably below the lower limit.

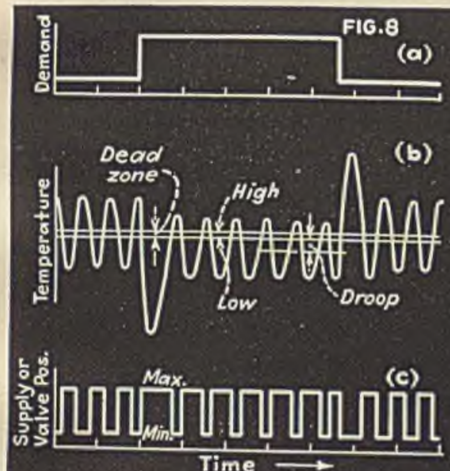
This introduces an important effect in automatic control which is generally called droop, offset, or load error. Types of controllers which exhibit this characteristic operate to maintain either the average or the instantaneous temperature within a band rather than at a single value. The magnitude of the droop is a function of the demand and its direction is usually opposite to that of the change in demand, that is, an increase in demand will cause the control to drop below the initial control point, whereas a decrease in demand will raise the control point. When the droop is too great to be tolerated, manual resetting of the control point is necessary in using such a controller.

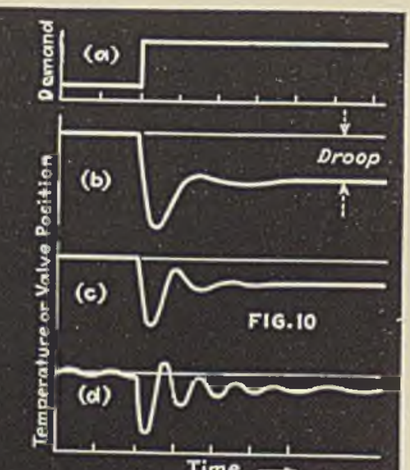
Fig. 8—Change in demand, controlled temperature variation, and changes in supply in two-position control of a process having considerable transfer lag

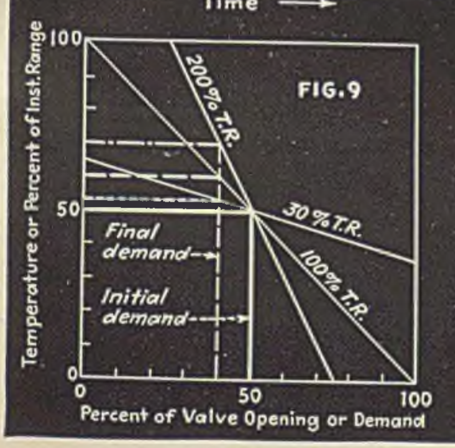
Fig. 9—Effect of demand changes and throttling range on the control point with a proportional-position controller

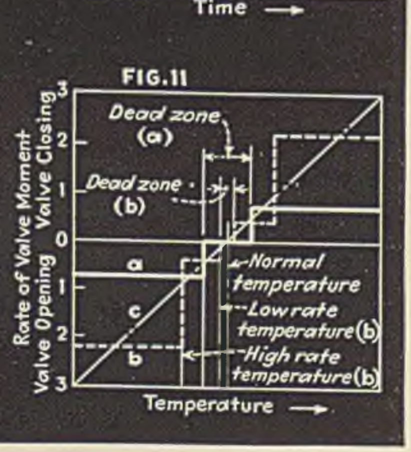
Fig. 10—Temperature response of a proportional-position controller to change in demand, with various widths of throttling range

Fig. 11—Valve movement responses to changes in temperature with single-speed, two-speed and proportional-speed floating controllers









It will be observed that in the middle range of Fig. 8, the average of the high and low temperatures is no longer at the initial control point, but droops considerably below it. If the process had only demand side capacity lag, the temperature changes would reverse immediately following a change in valve position, and there could be no droop. With steady demand the temperature record would be saw-toothed in pattern and confined within the high and low limits of the dead zone.

Thus it is seen that two-position control inevitably produces a cycling temperature and that it has a drooping characteristic in processes having transfer lag. Where these features are not objectionable, where the transfer lag is low, and where sudden changes in heating rate introduce no undesirable effects in the process, such as in combustion efficiency, two-position control is often the simplest and cheapest solution to a control problem.

PROPORTIONAL-POSITION CONTROL

In many processes continuous cycling of the valve is undesirable and a type of control in which the flow rate is continuously adjustable is preferred. One of the simplest of these is the so-called proportional-position or proportional control in which the controller selects a definite and different position for the final control valve for every temperature within the working range. This method of control introduces the concept of throttling range or proportional band, which is the range of values of the measuring element necessary to cause the final control valve to move from full shut to full open. The throttling range is generally expressed as a percentage of the full range of the control instrument and may be anything from a fraction of a percent to several hundred percent of the full range. Since the width of the throttling range has an important effect on the results obtained with the same controller applied to different processes, its width is generally adjustable in modern proportional instruments.

The fact that each position of the control valve is tied to a definite temperature with controllers of this type means that the instrument will control at a different point following every change in demand, which is another manifestation of the droop characteristic already discussed. Why this should be so will be evident from a consideration of the reason for the response of

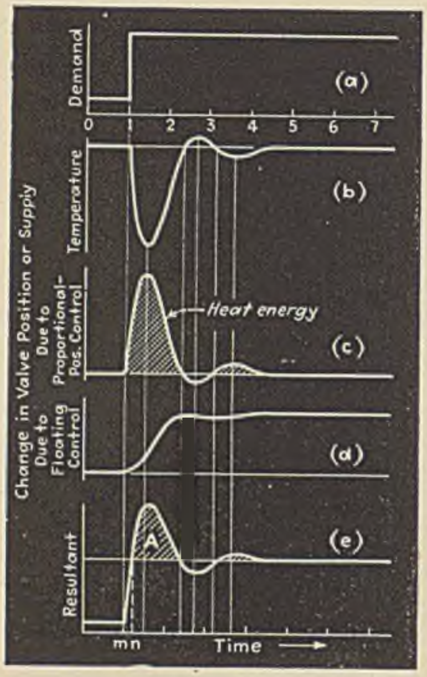


Fig. 12—Temperature and valve movement responses to change in demand of a proportional-plus-floating controller, showing effect of individual components

the controller. Assume that the controlled process is steady with the final control valve 50 percent open. If now the demand increases, the temperature will drop and the valve will open wider to increase the supply. But because the valve must have a definite opening for each temperature, therefore the new control point, with the wider open valve, must be below the initial control point. The situation is portrayed in Fig. 9 where, assuming that the supply response is proportional to the valve movements, the effect of a 10 percent decrease in demand is shown for throttling ranges of 30 percent, 100 percent, and 200 percent, assuming an initial temperature of 50. For the 30 percent range, the increase in control point is seen to be 3 percent of the instrument scale range (dotted line); for 100 percent, 10 percent of the range (dashed line); and for 200 percent, 20 percent of the scale range (dot-dash line).

EFFECT OF THROTTLING RANGE

Obviously, with a proportional controller, shift in the control point is limited to the width of the throttling range, so that only a small shift can take place if a narrower throttling range can be used. Unfortunately, as the throttling range is narrowed, any unfavorable process lags will introduce oscillations of increasing magnitude after a disturbance. Successive adjustments to reduce the throttling range still further will reach a point where sustained oscillations will be obtained. It is therefore necessary to operate such a controller with a throttling range of sufficient width to avoid continuous oscillation under the worst conditions that are likely to occur in the process. This increases the possible droop with demand changes, but deviation from the desired control point can be limited by manually changing the relationship between the measured temperature and the valve position.

The curves of Fig. 10 show the effect of the width of the throttling range on both the amount of the droop and stability. Curve (*a*) shows a sudden change in demand, while curves (*b*) to (*d*) show the resulting response of temperature (or valve position, which is proportional to it) for progressively narrower throttling ranges. In curve (*d*), the droop is slight, but it will be observed that the temperature has developed a slight sustained oscillation at the end of the record. The wide range adjustment of (*b*) would be satisfactory if only slight changes in demand were to be encountered.

FLOATING CONTROL

In another class of controller generally known as floating, the position of the final control valve bears no fixed relation to the temperature, but is changed continuously in the proper direction whenever the temperature deviates from the control point. Ordinarily, the rate of valve movement is made slow enough to avoid reaching one of the limits of its travel before it has been arrested by the return of the temperature to the control point. Since the valve remains in whatever position its movement is arrested, having no relation to the temperature, this instrument has no droop. On the other hand, to avoid constant cycling of the temperature, floating controllers of the constant-valve-speed type generally are provided with a dead zone. No control actions can take place, regardless of temperature changes, as long as the temperature remains within this dead zone.

Single-speed, two-speed and proportional-speed floating control actions are all employed, although for temperature control they are generally used in combination with proportional-position action, as explained later. A single-speed floating controller moves the valve continuously at constant speed as long as the temperature remains outside the dead zone. It is represented by controllers using a motor-operated final control valve and high and low control contacts in fixed position. The valve opens slowly but continuously, as long as the "high" contact is made, then, upon reversal of the temperature trend, remains in the position where the contact was broken until temperature has passed through the dead zone and completed the low contact. The two-speed floating controller employs two valve speeds, a low speed if the deviation is slight, and a higher speed if the deviation is large. This is easily accomplished by the use of two high and two low contacts, the low-speed contacts either inserting resistance in the motor circuit, or reducing the average motor speed by other suitable means. The proportional-speed floating controller differs from the foregoing types in two particulars: first, the valve speed is made proportional to the amount of temperature deviation; and second, the controller has little or no dead zone in most cases.

The way valve movement varies with deviation from the control point is shown for the three floating types in Fig. 11. Curve (*a*) for single-speed and curve (*b*) for two-speed floating controllers have a dead zone of temperature in which valve movement cannot take place, whereas the proportional-speed type shown by curve (*c*) has no dead zone.

Controllers of this type are not ordinarily satisfactory except in the virtual absence of process lags, which explains why they are seldom used in temperature control. Even demand side capacity lag is unfavorable in this case and successful application depends on the use of an extremely low valve speed. However, this type of control has become extremely important as an adjunct to the proportional-position controller where it has the function of resetting the control point automatically after demand changes so as to eliminate the droop ordinarily present in the proportional type. In such instruments the proportional-speed-floating form is usually employed.

PROPORTIONAL-PLUS-FLOATING CONTROL

In proportional control, the final control valve position is determined by the temperature, which means that the rate of valve movement is proportional to the rate of change of the deviation of the temperature from the control point. In a proportional-speed-floating controller, however, the ultimate valve position bears no relation to the temperature, the valve being moved at a rate proportional to the magnitude (not the rate of change) of the deviation. Therefore, if the two types of valve action can be superimposed, so that the valve is moved at a rate which is the sum of a rate proportional to the deviation from the control point, and the rate of change of this deviation, a method of control can be achieved which has the stability of the proportional controller, and the invariable control point of the floating controller. In this type the floating component requires no dead zone, since the proportional component introduces the stabilizing influence needed to prevent continued oscillation.

A great many controllers of this type, which are also known as proportional with automatic reset, or simply as reset controllers, are now in use. The action which takes place after a sudden load change with a proportional-plus-floating controller is analyzed in the curves of Fig. 12.

Assume that a sudden change in demand takes place at time (1) as in curve (*a*). With a well-adjusted proportional-plus-floating controller, the temperature might be brought back to the control point as in curve (*b*). Curve (*c*) shows the component of the valve movement due to proportional control alone, while curve (*d*) shows that due to floating control alone. Curve (*e*), their sum, shows how the control stabilizes at the new demand rate. When the demand change takes place at time (1) both types of control response go into action. The proportional control action, curve (*c*), serves to increase the valve opening while the temperature is decreasing, and to decrease it while the temperature is increasing, but has no permanent effect in determining the final valve position, its final effect on the valve position being zero after the temperature has returned to the control point. The floating control action, curve (*d*), operating the valve at a rate which is always proportional to the deviation, opens the valve as long as the temperature is low and closes it while it is high, eventually leaving the valve opening at that required for the new demand rate.

Since curves (*c*) to (*e*) are rate-of-supply curves (on the assumption that changes in rate of supply are always proportional to changes in valve opening), the areas under the curves can be taken as measures of quantities of heat supplied. That is, the areas represent the integrals of the curves between specified time limits, or

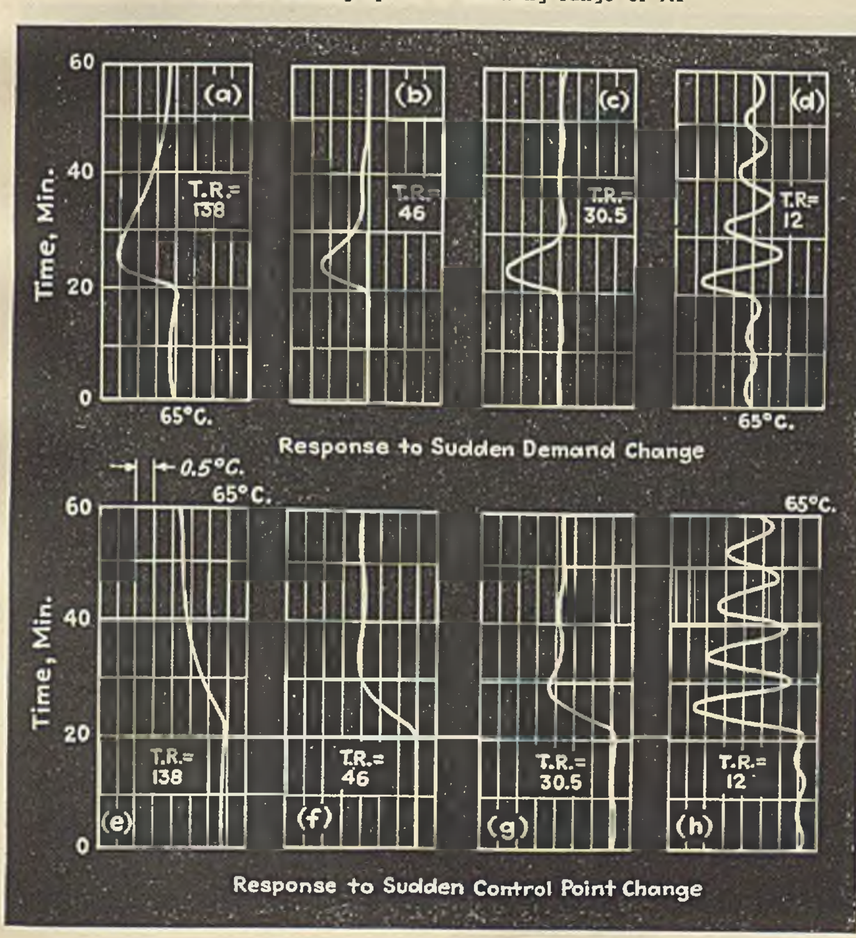
$$\text{Area} = k\int_{t=1}^{t=n} q\,dt$$

where k = a constant of proportionality; q = the rate of heat supply reckoned from a selected base rate as zero; and t = time. In Fig. 12 area A represents a quantity of heat supplied in excess of the new steady demand requirement which serves to replace stored energy lost during period *m-n* when the demand exceeded the supply; and also to increase the energy stored in the heater to that required for the new thermal head. It will be noted from curve (*b*), representing the temperature, that the controller has permitted no deviation of the control point.

The curves of Fig. 13 are reproductions of actual experimental curves obtained in tests of a proportional-plus-floating controller (J. C. Peters, Experimental Studies of Automatic Control, A.S.M.E. *Trans.*, April 1942, pp. 247-255). For these tests and those from which curves are reproduced in some of the later figures, a laboratory process for temperature control was devised, consisting of a small electrically heated water tank in which the head could be changed at will so as to alter the flow rate, and hence the demand. To introduce transfer lag a layer of insulation was interposed between the tank wall and the heater winding. To insure constancy of demand when such constancy was desired, the water supply to the tank came from another tank thermostatically controlled by means of a heater and a cooling coil. Water flow was adjusted manually by a constant head device and other precautions such as use of voltage regulation were taken to prevent spontaneous changes in demand or supply. Special circuits and equipment were used to insure accurate supply changes, in line with controller responses. Curves were made for a series of adjustments of both throttling range and floating speed, the adjustments being such that the ratio of floating speed to throttling range remained constant. (This arrangement is usual with controllers of this type. One adjustment is provided to change the floating time independent of the throttling range, but the other, for throttling range, also changes the floating time in a fixed proportion to the throttling range.) Curves (*a*) to (*d*) were drawn in response to a sudden change in demand, while curves (*e*) to (*h*) followed a sudden change in control point. With a wide throttling range, as in (*a*) and (*e*), the return to the control point is seen to be slow. On the other hand, with a much narrower throttling range, as in (*b*) and (*h*), the damping of the controller is slight and a long period is required to remove the oscillations. Curves (*b*) and (*f*) are not quite, and (*c*) and (*g*) are substantially critically damped.

It may also be instructive to observe the experimentally obtained results

Fig. 13—Experimentally obtained responses of a proportional-plus-floating controller to demand and control point changes, for various throttling ranges, but with a constant ratio of floating speed to throttling range of 7.1



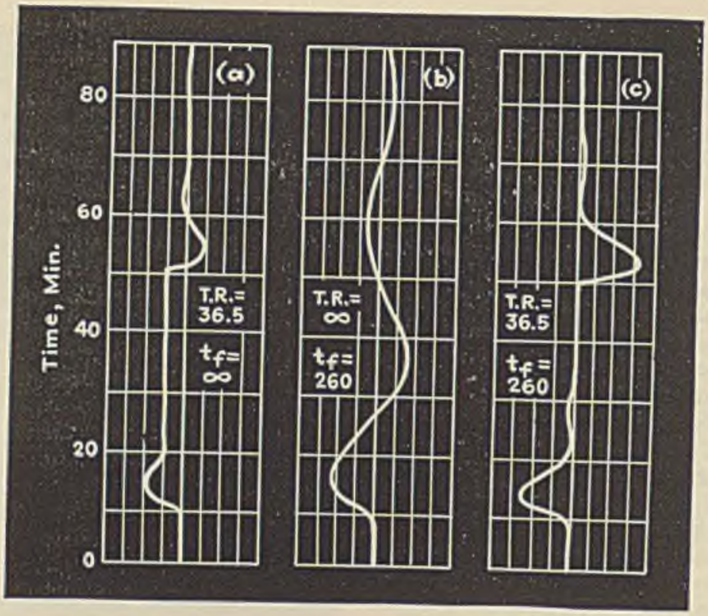


Fig. 14—Experimentally obtained responses of a controller to a demand change, at (a) using only proportional-position action, at (b) using only floating action, and at (c), using the sum of the two types of control action

(from the same A.S.M.E. paper) when proportional control alone, and floating control alone, are used. Fig. 14 reproduces three actual curves obtained in response to sudden demand changes, curve (*a*) with proportional control alone, and curve (*b*) with floating control only. In the former it will be observed that a shift of 0.5 deg. in control point took place after the change in demand, but that the control point returned to normal when the initial demand was resumed. In the second curve, with infinite throttling range (floating control only), the temperature cycled continuously about the control point. Curve (*c*) shows the rapid and stable return to the control point which is possible when the two types are superimposed, with the same adjustments used for (*a*) and (*b*). Fig. 15 shows how adjustment of the floating speed alone affected the control. All of these records were made with the same throttling range. Curves (*a*) to (*d*) show the response to a sudden change in demand, while (*e*) to (*h*) are for a sudden change in control point. Curve (*a*) shows a permanent shift in control point, being without floating action. Curves (*d*) and (*h*) have too great a floating speed, resulting in insufficient damping.

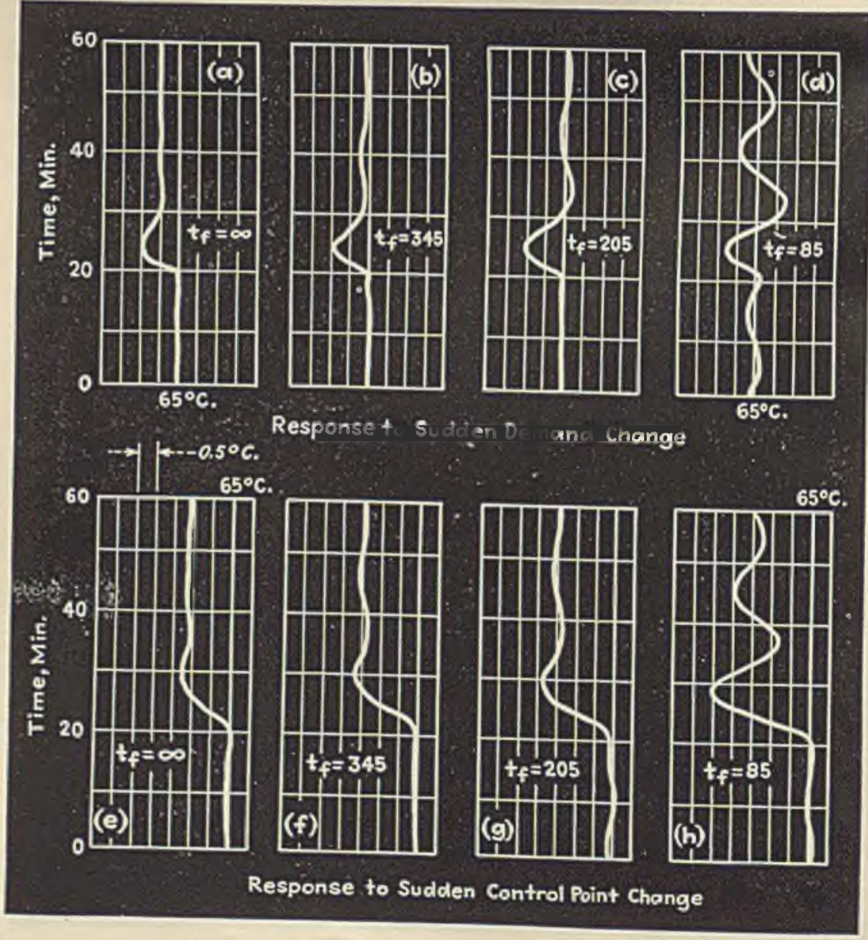
SECOND DERIVATIVE CONTROL

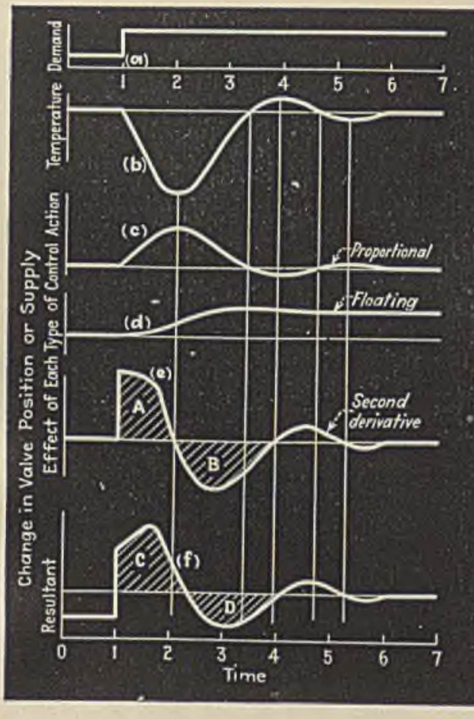
It has been explained how the additive combination of proportional and floating control actions results in stable control with exact return to the control point. It will now be shown how the addition to these of "second derivative" action can achieve a reduction in the magnitude and duration of deviations. The problem may be readily formulated from a consideration of Fig. 12 based on proportional-plus-floating control. It is evident that to check the deviation more quickly more heat energy must be supplied sooner and yet without decreasing stability. Increasing the strength of the proportional control action would increase the heating during the early stages of the deviation but would not satisfy the requirement as to stability. What is needed is some control effect that will call for a large change in valve position or rate of heating as soon as a deviation is noted and then call for a large change in the opposite direction well in advance of the return of the temperature to the control point. This type of action is obtained by making use of a control effect such that in addition to the effects of floating and proportional control, the final control valve is moved by amounts corresponding to changes in the rate of change of temperature.

The mathematical equation representing the action of a proportional-plus - floating - plus - second derivative controller, in response to changes in temperature, is:

Fig. 15—Experimentally obtained responses of a proportional-plus-floating controller with a constant throttling range of 36.5, while varying the floating time

(Floating time, t_f, is calculated time in minutes to full-stroke the valve through floating action alone, when deviation from control point is 1 percent of scale range.)





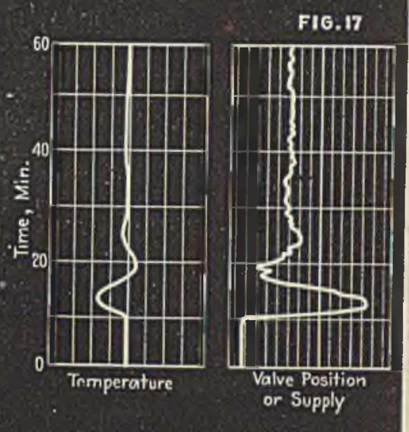


Fig. 16—Temperature and valve movement responses to a change in demand of a proportional-plus-floating-plus-second derivative controller, showing effect of individual components

Fig. 17—Experimentally obtained responses of a proportional-plus-floating-plus-second derivative controller to a sudden demand change

$$-\frac{dv}{dt} = A\theta + B\frac{d\theta}{dt} + C\frac{d^2\theta}{dt^2}$$

floating second derivative
proportional

where v = valve position; θ = deviation of temperature from the control point; t = time: and A, B, C, are constants.

Expressed in words this equation states that the rate of change of valve position with time, at any instant, is given by the sum of three components: the first component is proportional to the deviation of temperature from the control point; the second component is proportional to the rate of change of the deviation with time; and the third is proportional to the rate of change of the rate of change of the deviation with time. The three constants A, B, and C have values dependent upon adjustments made in fitting the controller to the process.

Fig. 16 presents a graphical analysis of the actions of a controller including the effect of second derivation control. In constructing the curves, a process of the general type of Fig. 5 was assumed. Change in demand was considered to represent the effect of a sudden change in the rate of flow of water through the tank, and controller lags were assumed to have negligible effect.

Referring now to Fig. 16, curve (*a*) shows a sudden sustained demand change taking place at time (1). Following the change in demand the temperature deviates from the control point as indicated at (*b*), setting up control actions which ultimately return it to the control point.

The component control actions are represented by curves (*c*), (*d*) and (*e*). Curve (*c*) for proportional control and curve (*d*) for floating control are the equivalent of curves (*c*) and (*d*) of Fig. 12 and requires no further explanation. Curve (*e*) for second derivative control displays the interesting characteristics of this type of action. When the temperature is steady, as before time (1) and after time (6), there is no second derivative effect in evidence. Also, when the temperature is momentarily changing at zero rate as when the direction of the temperature trend reverses, the second derivative effect is again zero. However, the instant that the temperature starts to deviate at time (1) this effect displaces the valve by a definite amount related to the initial rate of temperature change.

Like the proportional control component the second derivative component has no influence on the ultimate steady valve position, this being determined by the floating component only. It was noted previously that the proportional component introduces a large block of heat energy to provide stability. In Fig. 16 (*e*) shaded area A represents a large block of heat energy supplied, and area B a similar large block of heat energy removed, by second derivative action, also to the end of increasing stability.

Added together the three control effects of curves (*c*), (*d*) and (*e*) give curve (*f*). Shaded area C represents the addition of heat at a rate in excess of final requirements while area D represents heat supply at a rate below final requirements.

The effect of the addition of the second derivative component is such that when all three components are correctly adjusted to the process the area under the curve of temperature deviation can under ideal conditions be reduced by as much as one-half to three-fourths in application to processes with characteristics similar to those of Fig. 5.

Experimentally determined response curves for proportional-plus-floating-plus-second derivative control are set forth in Fig. 17. These are from the same A.S.M.E. paper previously mentioned. Comparing the valve-position curve of Fig. 17 with curve (*f*) of Fig. 16, the valve-position is seen to change much more suddenly in the later case. In actual practice the valve may respond quite rapidly following the indication of a temperature change but the rate is usually limited both by the initial rate of temperature change itself (because heat transfer to the primary sensitive element usually results in rounding the start of the temperature deviation curve) and because other controller lags limit the possible rate of valve movement.

It is evident from the curves of Fig. 16 that the second derivative control action is a very powerful one in so far as the transfer of energy is concerned. Since it calls for correspondingly large valve movements the range of its normal effect is more closely limited by the range of possible valve movement than in the case of proportional-plus-floating control only. Also any defective operation of the measuring or control mechanism, such as a tendency to stick or move in large steps, is likely to result in erratic valve movement.

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Instruments for Measuring and Controlling Process Variables

EDITORIAL STAFF REVIEW

This review attempts to explain all industrially important process variables, and show the principles of the various types of instruments which have been developed to measure and, if need be, control them. Since entire books have been written covering a much smaller part of the subject, it is obvious that we can touch only high spots, to recall principles which may have escaped the reader's mind.— *Editors.*

PROCESS INDUSTRIES have grown up around the measurement and control of process variables. In the early days of these industries, measurement was often intuitive, and control usually manual, but with the industrialization of chemical engineering types of operation and the demand for ever better yield and quality, and ever lower production costs, the duty of measuring and controlling has been delegated increasingly to industrial instruments. These devices can exert far higher measuring accuracy than is possible by the intuitive method. Their responses are untiring and generally unfailing. In most instances the control they are able to provide is much superior to manual control. In fact, practically every desirable characteristic with the exception of judgment can be built into them, and many are able to cope with so many contingencies that even this factor appears to be present.

Use of industrial instruments is now taken for granted and most engineers in process work are on terms of considerable familiarity with many of them. The reason why it seems worthwhile, then, to review a subject so well known to so many people is to bring as many phases of the subject as possible into one place, for quick and easy review.

In determining how a process shall be controlled, it is important to isolate all of the process variables that will be encountered, determine which are the independent variables and which will influence the process results enough to require control. Certain variables inherently will remain within suitable limits and so need not be controlled. Some will be found to be dependent on others fluctuating in definite relation to other variables or groups of variables, and will not require independent control, provided the variables on which they are dependent are themselves controlled.

Process variables may be classified in a number of different ways. One of the most convenient is on the basis of whether they are affected by (1) the energy state of the material, (2) the quantity or flow rate relations of the several materials in the process, or (3) the composition of the material. Another group of variables (4) relates to the flow of electricity in the process, either as the electrochemical driving force of the process, or as the means of supplying process heat or motive power.

Not only do industrial instruments measure and control process variables, but they also have a number of other functions (5) with which this article is also concerned. In addition to producing a measurement which may not be visible in the case of some controllers, they may indicate, record and sometimes totalize the measurement. Sometimes they control at a particular value of a variable, in other cases altering the control point according to a definite time schedule. They may be used to start various parts of the process at definite times and to control the duration of various operations. If desired, instruments can issue a warning or shut down the process in case a dangerous or otherwise undesirable condition is arising. They may be used to control one variable in a definite relation to another. Finally, instrument type devices are available for transmitting indications and control impulses over considerable distances without undue lag or loss of accuracy.

Another purpose of this article is to describe (6) the various types of devices used in conjunction with measuring instruments for the automatic control of process variables. In none of the descriptions will it be possible in an article attempting to cover as much territory as this one to go into detail. Sketches will necessarily be highly diagrammatic, indicating only the principles involved, and not the exact or detailed construction, while descriptions will necessarily be pared close to the vanishing point.

1. ENERGY VARIABLES

Process variables of this group, relating to the energy of the material, include:

(*a*) Temperature
(*b*) Pressure and vacuum.

(*a*) Temperature is a thermal potential, comparable to a pressure head or an electrical voltage. In conjunction with the specific heat of the material, it is a measure of the amount of heat energy contained in the material. It cannot be measured directly, but must be inferred from the properties of the material, or from those of another material in thermal equilibrium with it. It may be inferred from the expansion of solids, liquids or gases; from the vapor tension of a liquid; from the electrical resistance of materials, usually solids; from the thermoelectric potential produced by dissimilar metals in contact; from the intensity of the total radiation, or of a particular band of wavelengths of radiation given off by the hot body; and from changes of state of solids, liquids, or gases.

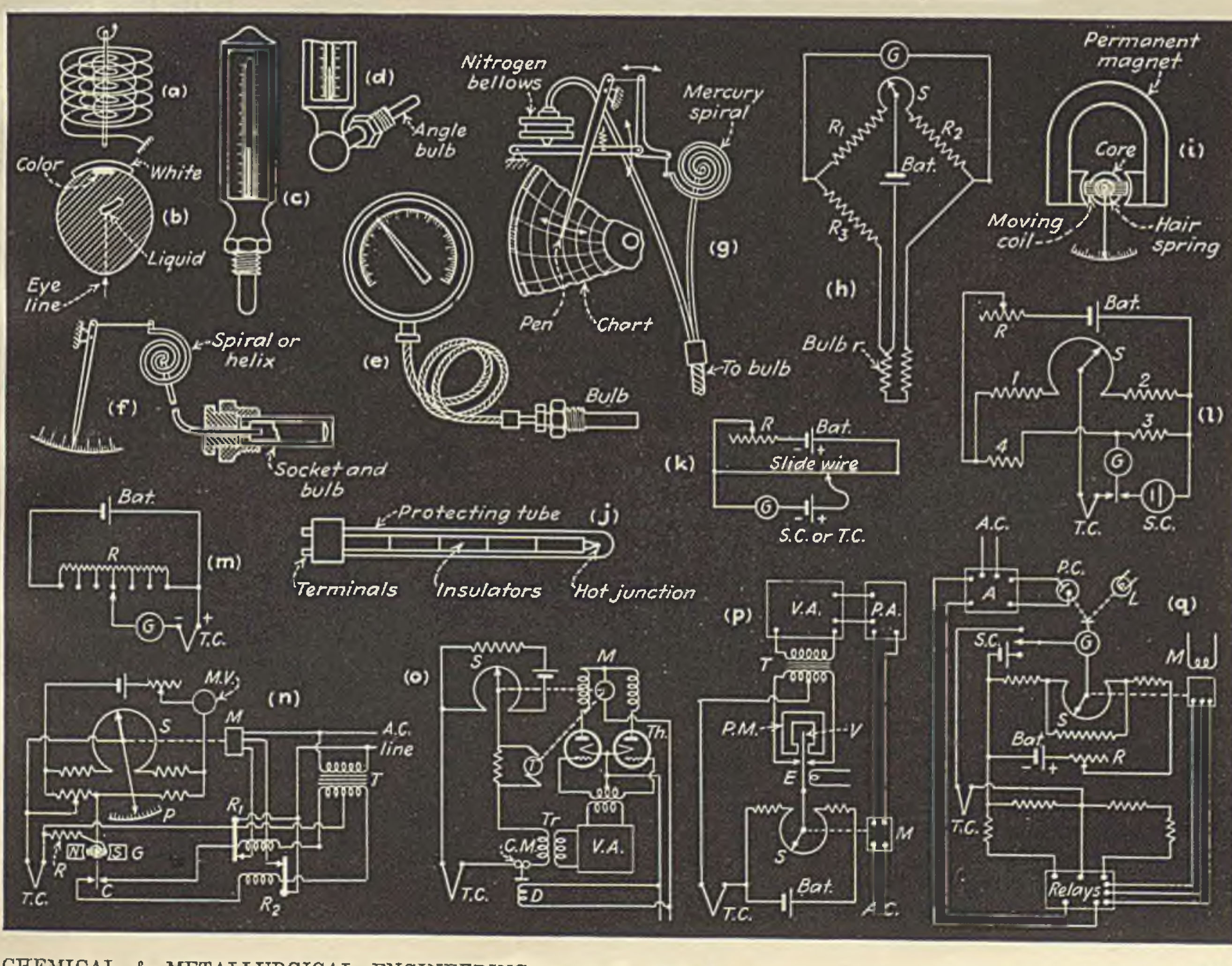
It is manifestly impossible to describe here all the numerous embodiments of temperature measuring principles that have been developed. An attempt will be made, however, to cover briefly the methods of industrial significance. Measurement of the expansion of liquids and gases is the most used method, while probably the method of next most importance is the one employing the thermoelectric effects of dissimilar metals in contact.

Such measuring methods are diagrammed in Fig. 1 and Fig. 2 (*a*) to (*e*). Fig. 1 (*a*) represents a modern type of "coils within coils" bimetallic spiral thermometer (Weston) in which a large deflection is secured with a light and sensitive bimetal on account of its extreme length. One end of the coil is anchored; the other end is attached to the pointer shaft. Ordinarily bimetals are shorter and heavier, giving more lag and less accuracy. Sketches (*b*) to (*g*) deal with fluid thermometers. Sketch (*b*) is a cross-section of one type of improved thermometer tubing in which the liquid column is reflected in the colored backing, whereas reflection in the tubing itself makes the backing invisible above the top of the liquid column. Another improvement that should be mentioned is Binoc tubing (Taylor), which by a three-lobed lens construction to the tubing makes the mercury column visible over a much wider angle than normally. In (*c*) and (*d*) are two forms of industrial thermometer, a straight and an angle-bulb type. Such thermometers generally employ mercury as the filling liquid. In (e) is an indicating fluid-filled thermometer illustrating a different principle of indication, namely use of the pressure of the fluid filling, which is related to the temperature, to position a pointer on a scale. This type employs various liquids such as mercury or certain organic compounds, as well as gas (usually nitrogen); or a partial fill of a volatile liquid. In the case of a gas or solid liquid fill, the scale is evenly divided, while in the case of a partial fill with liquid of high vapor tension at the temperature of use, pressure increases more rapidly than temperature and hence spreads the scale in the upper range, giving uneven divisions. One type of actuation employed in pressure-type thermometers is illustrated at (f). The system consists of a bulb, generally inclosed in a protective socket, connected by capillary tubing to an element capable of expanding or otherwise altering its dimensions under increasing pressure. This element may be a spiral or helix of flattened tubing which tends to straighten and hence uncoil with increasing pressure, or it may be an expansible capsule or diaphragm. Whatever the element, it is connected by a linkage to a pointer or pen moving over an indicating scale.

A difficulty encountered with pressure-type thermometers, particularly with mercury-filled thermometers, is the false indication resulting from volume changes of the fluid in the capillary in case of temperature variations along this tube. This generally limits uncompensated mercury pressure thermometers to a maximum capillary length of 10 to 25 ft. Several compensating methods have been developed, one of which is shown in sketch (g). This method (Tagliabue) is suitable for distances up to several hundred feet. A second capillary, inclosed in the same sheath with the mercury tube, but blanked off before it reaches the bulb, is connected to a capsular element and filled with nitrogen. Any temperature effects on the mercury in the mercury capillary are compensated by the lever and movable pivot system shown. Another compensating method (Taylor) uses a larger diameter mercury capillary in which is a wire of a special alloy. The temperature effect on the wire and capillary itself is just sufficient to offset effects on the mercury in the capillary.

Another temperature measuring device which is known as a thermometer, although it is suitable for measurement of temperatures from the lowest measurable to the high-temperature range, is the resistance thermometer. The thermometer element is a carefully constructed coil of nickel or platinum wire which is installed as one arm of a wheatstone bridge circuit as shown in Fig. 1 (h). Resistances R_1, R_2 and R_3 are equal and of a metal of low-temperature coefficient of resistance, usually manganin. These three resistances and the bulb r are usually all of the same resistance at room temperature. In use, any unbalance of galvanometer G due to variation in resistance of r with temperature change can be compensated by moving slidewire S which is calibrated in temperature. Or, the temperature can be read directly by the deflection of a millivoltmeter substituted for G, without the use of a slidewire. The first or null method is largely favored and employs a self-balancing instrument for adjusting the slidewire until the galvanometer deflection is zero. Numerous relatively complex but reliable mechanisms have been developed for this purpose. In the past, these were largely mechanical, but a recent tendency has become evident to employ electronic devices for balancing if speed is required. In the mechanical and semi-mechanical methods, the galvanometer pointer is permitted to swing freely at intervals to determine whether unbalance exists. Galvanometers are sensitive electrical devices, generally employing a moving coil and a permanent magnet (d'Arsonval type) as in sketch (i), the coil being returned to the position shown by a hair spring after a deflection. Balancing mechanisms generally clamp the pointer periodically and if it is deflected, sense its location with steps or fingers which, in moving to the pointer, turn a drum on which a slidewire is wound in the direction to correct the

Fig. 1—Diagrams illustrating principles of a variety of temperature-measuring instruments



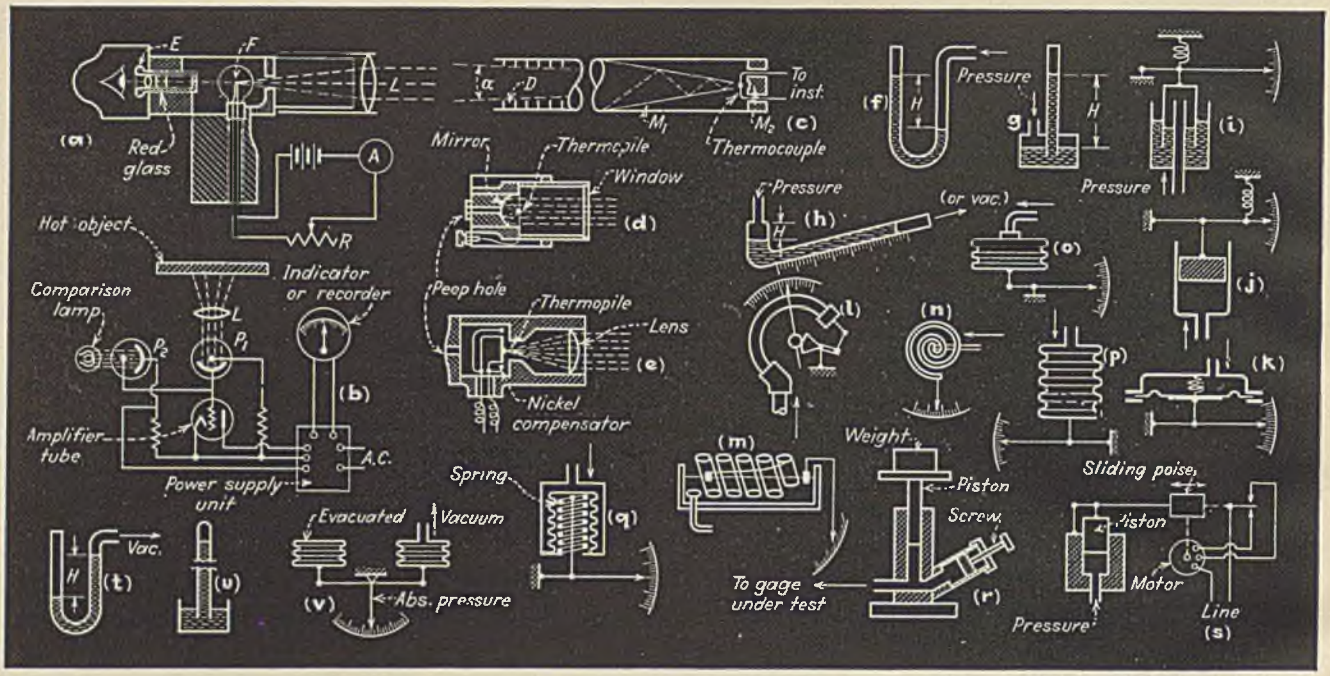


Fig. 2—Sketches (a) to (e), temperature-measuring instruments; sketches (f) to (v), pressure-measuring devices

unbalance. The pointer is then freed, and if unbalance still exists, the cycle is repeated until the circuit is again balanced.

Thermoelectric pyrometers are the most important device for measuring high temperatures, as well as temperatures considerably below atmospheric. They also find considerable use for moderate temperatures. Fig. 1 (*j*) shows a typical thermocouple. The thermocouple consists of two dissimilar metal wires joined at one end which is known as the hot junction. These wires are generally threaded through insulating bushings, and inclosed in a tube. When such a thermocouple is heated at one end, while the free ends (terminals) are kept at a known temperature, a potential is set up between the terminals which is related to the hot junction temperature. This potential can then be measured by a millivoltmeter calibrated in temperature. There is at present no perfect theoretical explanation for the thermoelectric effect.

Several different combinations of metals are used for thermocouples, depending on the temperature of use. The effort in every case is to employ a combination which will yield a straight-line relation between potential and temperature. The principal combinations used include platinum and platinum-10 percent rhodium for the highest temperatures; and a number of base metal couples for lower temperature ranges including chromel-alumel; iron-constantan; copper-constantan; and chromel-copel. One of the first considerations in using a thermocouple for temperature measurement is to make certain that the temperature of the terminals (called the cold junction) is known, since the potential produced depends on the difference between the cold and the hot junction temperatures. Formerly many devices were used to insure such a constant cold-junction temperature, including burial of the cold junction in the ground, placing it in a thermostatically-heated box, or keeping it at the temperature of melting ice. At present most thermocouple installations extend the cold junction to the measuring instrument by the use of compensating lead wires which, in the case of the base metal couples, are usually flexible, multi-strand wires of the same material as the corresponding thermocouple elements, and in the case of noble metal couples, are of copper and a copper-nickel alloy wire (Bristol) having substantially the same thermoelectric characteristics as platinum and the platinum-rhodium alloy used. By this method, it is possible to make any necessary cold junction correction in the instrument case by use of a bimetal to shift the instrument zero; by use of a nickel shunt across the thermocouple leads, which varies with temperature; or by some equivalent method.

Although it is possible to measure the temperature of a thermocouple directly by means of a millivoltmeter, this method introduces as a possible variable the resistance of the leads and various connections. Consequently, a potentiometer is generally used as the measuring circuit, since in this method resistance is ruled out as a variable, owing to the fact that the thermocouple potential is balanced against an equal and opposite potential produced by a battery. Fig. 1 (*k*) shows an elementary potentiometer circuit. In the upper circuit, the battery produces a potential drop in the slidewire which may be adjusted by resistance *R*. In the lower circuit an opposite potential is produced by a standard cell of definitely known voltage, and the drop in the slidewire can be made equal and opposite to that produced by the battery by adjustment of the slider, this point being indicated by a zero reading of the galvanometer. A thermocouple can then be substituted for the standard cell, and the galvanometer again brought to zero by adjusting the slider. The relation between the first and second slider readings is a measure of the difference between the thermocouple potential and that of the standard cell, and the slidewire positions may be calibrated in terms of the temperatures of the hot junction corresponding to the various potentials. Sketch (*l*) shows a self-balancing potentiometer circuit with automatic compensation for the cold junction temperature. By means of the switch shown the standard cell is thrown into the circuit to permit standardizing the dry battery with resistance *R*. Then the thermocouple is thrown into the circuit for temperature measurement. Resistances 1, 2 and 3 are of manganin, while resistance 4 is of nickel, for cold-junction compensation. An automatic balancing mechanism for galvanometer *G* balances the potentiometer circuit by movement of slidewire *S*. A circuit similar to this is ordinarily used. Occasionally a deflection potentiometer circuit similar to sketch (*m*) is used in which only a part of the thermocouple potential is balanced against the battery potential, the remainder being indicated by the deflection of the galvanometer. The method is sometimes employed in indicating instruments, where rather small temperature fluctuations are expected. Each point shown might, for example, represent 10 deg. temperature difference, while the deflection of the galvanometer would show temperature variations, for example, from 0 to 10 deg.

Several of the newer potentiometer circuits are shown in Fig. 1 (n) to (q). At (n) is a simplified version of the Pyromaster circuit (Bristol) which employs a contacting galvanometer to balance the circuit. *M.V.* represents a millivoltmeter for standardizing the circuit, *S* the slidewire, *P* the chart pointer, *G* the galvanometer, and *C* the galvanometer contact. *R* is a resistance which as soon as contact takes place automatically increases the galvanometer current to increase the strength of contact in the proper direction. When contact is made, indicating unbalance in one direction or the other, the appropriate relay R_1 or R_2 is energized, energizing either the forward or reversing windings of the motor *M*. The motor then runs to reposition the slider on the slidewire, until contact is no longer made at *C*. Sketch (o) illustrates the Speedomax (Leeds & Northrup) which employs no galvanometer. *S* is the slidewire of the potentiometer, the contact of which is positioned by motor *M*. The potential produced by the thermocouple is put through a carbon microphone, *C.M.*, which is vibrated by a microphone drive *D*. This produces an interrupted current in transformer *Tr*, the alternating current component of which is put through a voltage amplifier *V.A.* The output of this amplifier in turn is fed to two thyratron tubes *Th*. The voltage of these tubes comes from the same supply line that feeds the microphone vibrator. When the thermocouple current changes, unbalancing the potentiometer, current may flow in either direction through transformer *Tr*. The phase of the alternating current fed to the voltage amplifier will depend on the direction of current flow, and this phase in turn will determine which thyratron supplies current to the motor and hence, which direction the motor will turn. The slidewire contact is then moved in the proper direction to achieve balance. To avoid overshooting, the drive motor is coupled to a tachometer magneto *T*, the potential of which is applied to the thermocouple circuit in the direction to oppose the thermocouple potential. This circuit is extremely rapid, permitting the pen to traverse a 10-in. chart in 2 seconds without overshooting.

Sketch (p) of Fig. 1 shows a simplified version of the Continuous-Balance potentiometer (Brown). Here slidewire contact *S* is positioned by motor *M* through the action of a vibrator *V*. Again, a current flow in the thermocouple circuit due to unbalance of the potentiometer may be in either direction. The vibrating reed *V* is vibrated at 60 cycles between the poles of a permanent magnet *P.M.*, by means of an energizing coil *E*. By means of the two contacts shown, this direct current is alternated through the primary of transformer *T* and the alternating secondary current is then applied to an electronic voltage amplifier *V.A.* and power amplifier *P.A.*, the output of which is applied to the motor *M* to achieve balance. As in the system illustrated in (o) the direction of unbalance determines the phase relation between the generated alternating voltage and the a.c. supply voltage. Rising temperature produces an in-phase relation and falling temperature, a 180-deg. out-of-phase relation. The motor used is a two-phase reversible motor and the direction of its rotation depends on whether one phase is lagging or leading the other. Hence the motor selects the proper direction of rotation to return the slidewire contact toward the balance point.

Still a different system of potentiometer balancing is found in the Celectray (Tagliabue) system. This instrument, Fig. 1 (q), employs a mirror galvanometer *G* which reflects a beam of light on or off a photocell *P.C.* to control the balancing motor. In this diagram *A* is an electronic amplifier for the photocell current, *L* is an incandescent lamp, *M* is the balancing motor, *S* is the slidewire, *R* is the potentiometer standardizing resistance, *S.C.* is the standard cell which may be substituted in the circuit for the thermocouple for standardizing, and "*Relays*" represent a pair of relays energized by the amplifier output, one controlling the forward and the other the reversing winding of the motor. When both relays are closed the motor moves the slidewire contact up-scale, and when both are open, moves it down-scale. One relay incorporates a time delay to avoid energizing the motor with rapid swings of the galvanometer.

It has been recognized for many years that the color radiated by a hot object is a measure of its temperature. Two methods are based on measurements of radiation, the optical pyrometer which measures the intensity of radiation of a particular wavelength given off by the hot object; and the radiation pyrometer, which measures the intensity of all radiation. Noble metal thermocouples are unsatisfactory above about 3,000 deg. F., so that for higher temperatures another method is necessary. In the case of the optical pyrometer the intensities of radiation in a limited portion of the spectrum is measured. The method is not exact since the intensity of all wavelengths does not increase in the same proportion as increase in temperature. Another difficulty is that the radiating body may not be under true black-body conditions, although objects within furnaces generally radiate approximately as if they were true black bodies, that is, bodies which absorb all radiation falling upon them and reflect and transmit none.

The method depends upon a comparison of the black-body temperatures of two radiating bodies by comparing the intensity of light of a given wavelength given off by each. The commonest method of doing this is by means of the disappearing-filament pyrometer, one type of which is sketched in Fig. 2 (a). This instrument (Leeds & Northrup) requires an incandescent filament for comparison. Light from the radiating body enters through lens *L* and is viewed through eye-piece *E*. Then the temperature of filament *F* is altered by means of adjustable resistance *R* until the filament disappears against the background of the hot object, at which point the filament current measured by milliammeter *A* is a measure of the black-body temperature. A red glass interposed between the eye-piece and the filament gives monochromatic light. Several other optical pyrometers have been introduced requiring visual comparison. However, the advent of photoelectric cells has made it possible to produce an optical pyrometer not requiring visual comparison. The Optimatic (Brown) shown in Fig. 2 (b) is such a pyrometer. Photocells P_1 and P_2 respectively measure light from the object and from a standard lamp used for comparison. The cells are part of an a.c. bridge circuit which uses an amplifier tube instead of a galvanometer. In operation light from the heated body strikes the exposed photocell P_1, varying its resistance and unbalancing the bridge. A change in the output of the amplifying tube changes the flow of current to the comparison lamp so as to rebalance the bridge. A meter then indicates or records the lamp circuit current in terms of the measured temperature.

The total radiation pyrometer, of which types are shown in Fig. 2 (c) to (e), has an advantage over optical pyrometers (except the photoelectric pyrometer) in not requiring visual comparison. The total radiation from a hot body is generally less than that from a true black body at the same temperature, but this can usually be corrected for adequately. Instruments of this type are made in two general forms, the fixed-focus and the adjustable-focus type. The radiation from a particular area of the hot body is concentrated on the hot junction of a thermocouple, or thermopile (group of thermocouples in series), and the thermocouple potential indicates the intensity of all radiation reaching it. In Fig. 2 (c) a non-focusing type (Thwing) is shown. This consists of a tube containing non-reflecting surfaces *D* at the entrance, a conical mirror M_1 and a concave mirror M_2 which concentrates the radiation on the thermocouple. The quantity of radiation reaching the thermocouple is independent of the distance to the hot body, provided the area of the latter is large enough to fill the angle a defined by the diameter of the entrance opening, and the length of tube to the thermocouple. Fig. 2 (d) shows the mirror type Rayotube (Leeds & Northrup) in which a mirror focuses rays from the hot object through a window on to a radial thermopile. A peephole is provided for aiming on the object. A somewhat similar instrument is shown in Fig. 2 (e). This is the Radiamatic (Brown) which uses a lens instead of a mirror to concentrate rays on the center of a radial thermopile. This instrument has a nickel compensating coil near the cold junctions of the thermopile, which is shunted across the leads to compensate for variations of the cold junction temperature. This instrument also employs a peephole for aiming.

(b) *Pressure*—Pressure is a force per unit area. In most cases it is measured directly by balancing against a known force, rather than by inferential methods such as are required for temperature measuring. The known force may be that of a liquid column, a spring- or weight-loaded piston, or a spring-loaded diaphragm or other element capable of distortion under the application of pressure. Inferential methods are sometimes used, such as that of measuring the thermal conductivity of the material (Pirani gage); or measuring the potential produced by a piezo-electric crystal under pressure.

The sketches of Fig. 2 (*f*) to (*v*) inclusive show a number of methods of measuring pressure. Sketch (*f*) shows a simple U-tube manometer in which, knowing the density of the manometer liquid, the head *H* is a measure of the pressure in comparison with that of the atmosphere. Sketch (*g*) shows a simple well-type manometer with *H* again a measure of the pressure. For the measurement of small pressures or vacua, the inclined tube manometer shown at (*h*) is often used, since the head can be multiplied several times by the sloping liquid column. The inclined tube, however, is not readily adapted to recording instruments, so for small pressures, a liquid-sealed bell is often employed. In this case, sketch (*i*), the weight of the bell is shown supported by a spring, the pressure raising the bell and counteracting a part of the spring tension. An occasionally used method of pressure measurements, as in engine indicators, is shown in sketch (*j*) which shows a piston and spring combination.

There are various other spring elements also possible for pressure and vacuum measurements. For example, sketch (*k*) shows a spring-weighted slack diaphragm. The bourdon tube, which consists of a bent and flattened metal tube, is itself a spring, which tends to straighten by an amount proportional to the increase in pressure. This tube is shown at (*l*), while the helical element (*m*) and the spiral element (*n*) are spring elements similar to the bourdon tube, except that they are of greater length in order to secure greater deflection for a given pressure change. The capsular element shown in (*o*) also distorts against its own springiness. Sketch (*p*) shows a bellows element which, owing to its springiness, is sometimes used without an additional spring for pressure measurements. It is also provided with a spring as in sketch (*q*) for greater strength or to secure more accurate calibration.

The sketch of Fig. 2 (*r*) shows a dead-weight tester which is the fundamental method of producing pressures for the testing of pressure gages. Here a piston of known area, weighted with a known weight, produces a known pressure in the cylinder which can be communicated to a pressure gage. In use the screw-operated piston is used to force liquid into the cylinder so that the pressure piston is raised. To avoid friction effects, measurements are made with the weight table turning slowly. This principle has been employed in an automatically operating dead-weight gage (Bailey) for measuring and transmitting high pressures electrically. A piston, continuously rotated to a motor, is opposed to the pressure. A change in pressure, causing the piston to move upward or downward, operates a pilot valve controlling the flow of oil to a piston in a cylinder which positions a displacer in a mercury cup carried by the pressure piston. This in turn varies the load on the pressure piston and returns it to its initial position. The height of the displacer can be telemetered to a distant point and this indication recorded as pressure. Another automatically balanced piston gage is shown in sketch (*s*). Here pressure on the piston is opposed by a scale beam carrying a poise. Movement of the scale beam closes high or low contacts, operating a reversing motor which balances the poise.

Vacuum gages are shown in sketches (*t*) to (*v*). A simple U-tube gage for low vacuum, which is identical with the gage of sketch (*f*) is shown in (*t*). Sketch (*u*) illustrates the barometer, used to measure the pressure of the atmosphere. Up to this point all pressure-measuring methods that have been described, it will be noted, have measured pressure above that of the atmosphere. If it is desired to measure absolute pressure, the arrangement of sketch (*v*) is employed. Here two aneroids (bellows) are used, one evacuated to substantially zero pressure, and the other to the vacuum to be measured. The indication achieved by the balance between these two aneroids is thus corrected for atmospheric pressure variations and can be calibrated in terms of absolute pressure.

2. QUANTITY AND RATE VARIABLES

The variables of this group, relating to quantities and flow rates of materials in a process, include:

(*a*) Fluid flow rate
(*b*) Liquid level
(*c*) Weight and weight-flow rate of solids and liquids
(*d*) Thickness and other dimensions of solids
(*e*) Speed of processing machinery.

(*a*) *Fluid Flow*—Fluid flow rate is one of the most important process variables. It is measured directly by volumetric devices such as positive displacement meters, but to an even greater extent, it is measured inferentially. In the latter class are head, area, current or velocity type and energy-adding meters.

Included among the positive displacement meters are various arrangements of pistons, gears, diaphragms, rotating pistons and rotating buckets. Fig. 3(a) is a diagrammatic scheme, not actually used, but designed to illustrate the principle of reciprocating piston meters. Under pressure of the fluid being metered, the piston shuttles back and forth, shifting the intake and discharge valves as it reaches the end of its stroke and operating a counter to add a fixed flow increment with each stroke. Another type of piston meter, a two-cylinder rayon spinning pump, is diagrammed in sketch (*b*). While this device is used as a pump, it is also a constant displacement meter. The cylinder rotates causing reciprocation of the pistons which are secured to a swash plate of adjustable angle. By means of this adjustment, the delivery of the pump per revolution can be adjusted precisely. A type of meter employing rotating impellers for positive displacement is illustrated in sketch (*c*). This type (Roots) may be considered the limit of a gear pump, sketch (*d*), which can also be used as a positive displacement meter. The common nutating disk meter, used for domestic water metering, and shown in sketch (*e*), uses a form of rotating piston. The tilted disk is cut by a stationary vertical partition near the discharge which causes the space above and below the disk to form separate chambers. The pressure of water passing through then causes the disk to describe a continuous nutating action, causing rotation of a counter.

A number of elementary types of constant volume meter in addition to those mentioned have been developed. The primative tilting box type shown in sketch (*f*) of Fig. 3 is probably not used today, but has been used in the past. The condensate meter shown in sketch (*g*) is, however, a modern development of this idea. The vanes shown here in cross-section are closed at the ends to form buckets which rotate at a rate directly proportional to the flow. A rather similar principle is employed in the water-sealed gas meter, frequently used in gas plants. This meter shown in sketch (*h*) uses water contained in the lower half of a casing as a sealing and valving agent to control the passage of gas into the various compartments which are caused to rotate by the pressure of the gas. A different, more complex principle is used in the ordinary domestic diaphragm-type gas meter. Sketch (*i*) attempts to illustrate the principle. This type of meter is difficult to portray in a simple sketch and the diagram is merely suggestive. Two partitions and two diagrams form four chambers numbered 1, 2, 3 and 4. Reciprocation of the diaphragms operates cranks which in turn rotate a single crankshaft driving the counter and the slide valves which alternately connect the chambers with the inlet end of the box and with the discharge.

Sketch (*j*) of Fig. 3 illustrates the meter prover which is merely a small water-sealed gas holder in which a known volume of gas at adjustable pressure can be stored. Since the amount of gas which it discharges can be determined exactly, this device is often used for meter testing and calibration.

Head Meters—Meters so far considered measure the volume of flow, rather than the rate of flow. Meters still to be considered are all rate-of-flow meters. Those types designated as head meters are, as a class, the most important in this group. Most used are those devices which measure the pressure drop in a fluid flowing in a closed conduit, caused by an obstruction such as an orifice, venturi, or flow nozzle. Less important is the pitot tube, which measures the difference between the impact pressure head and the static pressure head in a fluid flowing in a closed conduit; and the weir meter which determines the flow rate of liquid flowing in an open channel by measuring the height of the crest above a dam over which the liquid is flowing, or above the bottom of a notch cut in the dam through which the flow passes. Such meters all employ either

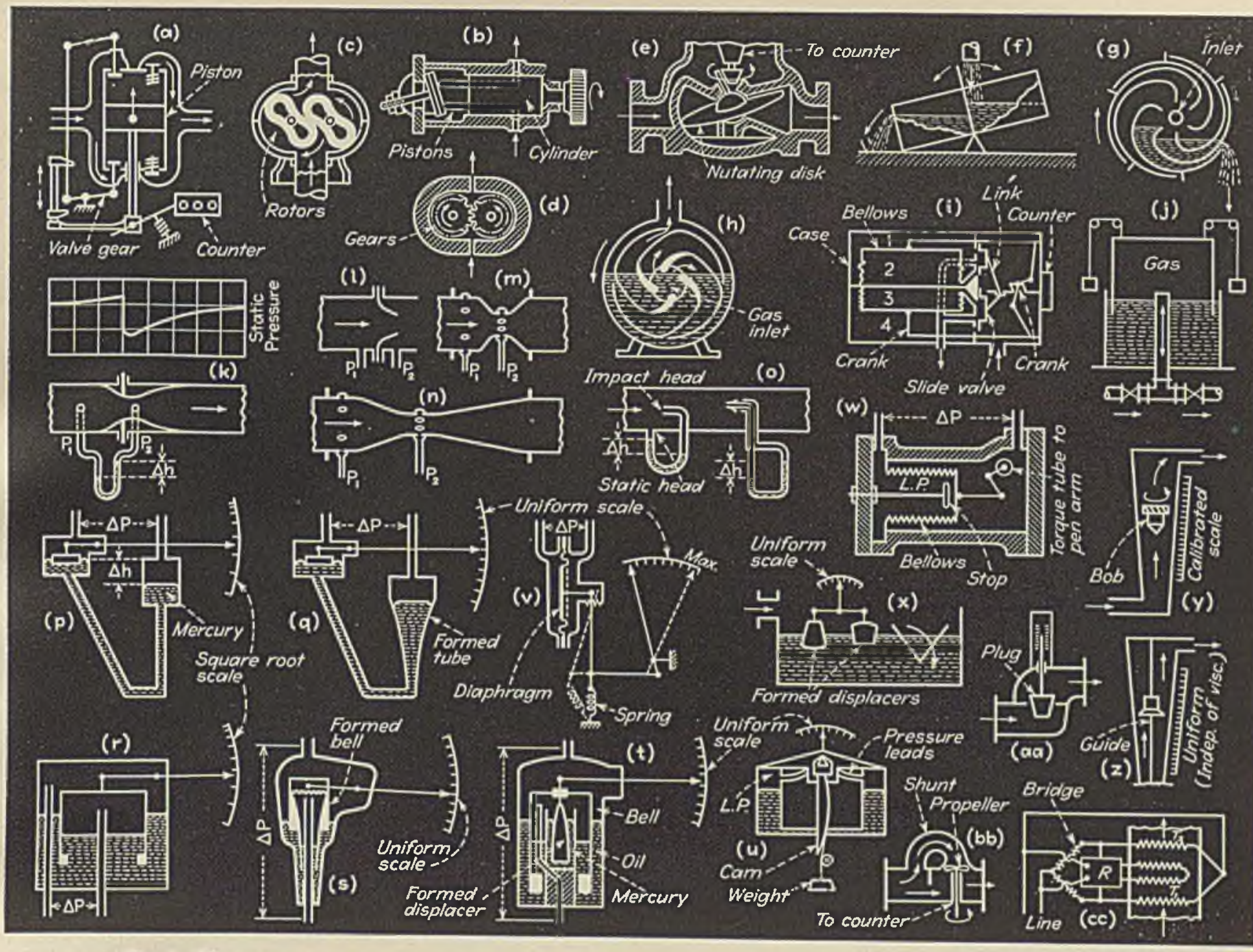


Fig. 3—Diagrams of instruments and other devices for the measurement of flow volume and flow rate

a differential pressure or a head which can be taken as a measure of the flow rate.

At this point, the problem of totalizing the flow passing through a meter should be mentioned. Numerous ingenious devices have been developed for this purpose. Simple counters can be used with positive displacement meters and with weighing devices for liquids (or solids) which discharge fixed increments of material. However, in the case of rate-of-flow meters, the meter must solve the integral of qdt, that is, must sum up the succession of instantaneous flow increments measured, in addition to extracting the root of the measured quantity which is characteristic of the measuring method. With differential pressure instruments (orifices, venturis, flow nozzles and pitot tubes) the meter must extract the square root of the differential. With weirs, it must extract the $\frac{3}{2}$ root of the crest height, since with the first class the flow rate is proportional to the square root of the differential, and with the second class, to the $\frac{3}{2}$ root of the crest height. In several of the meters about to be described, it will be shown how the meter automatically performs this mathematical operation.

The sketch of Fig. 3 (*k*) shows the orifice in thin plate which is the commonest differential pressure producer. The variation in static pressure across the orifice is shown approximately in the graph. The pressure taps, P_1 and P_2, are shown connected to a differential pressure manometer. The downstream location P_2 is at the "vena contracta" or point of maximum contraction of the stream. Although this location gives best reproducibility of results, flange connections which give a different calibration, and a smaller differential, are also used to a considerable extent. Sketch (*l*) shows a flow nozzle, a type of orifice sometimes used for large flows, particularly where considerable pressure recovery is necessary. Sketch (*m*) shows a venturi nozzle, an alternate for the flow nozzle, used also where good pressure recovery is necessary. The venturi tube proper shown at (*n*) has a discharge coefficient close to unity and is capable of nearly complete downstream pressure recovery. It is used principally for large flows of water. Another type of differential pressure producer, the pitot tube, is shown in sketch (*o*) which illustrates two variations of this device. The difference between the impact and static heads at a point in a flowing fluid in a closed duct is a direct measure of the velocity head, $V^2/2g$, and this device is sometimes used where another type of differential producer cannot be used. It has the disadvantage of measuring flow velocity only at a particular point, rather than the average through the duct, so that care must be taken in making certain that its location is actually at a point of average velocity.

Sketches Fig. 3 (*p*) to (*w*) show methods of measuring differential pressures. Sketch (*p*) shows the common float type mercury manometer which gives a direct measure of the pressure differential $\Delta\ p$, which is proportional to the square of the flow rate. A scale calibrated in flow is, therefore, unevenly divided. Many methods are used for extracting the square root of the differential. One common method is to interpose a shaped cam between the float and the pointer. Another useful method, shown in (*q*), is to employ a specially formed tube for one leg of the manometer. Other methods are shown in sketches (*s*), (*t*), (*u*) and (*v*). For lower pressure ranges floating-bell manometers are often used as in sketch (*r*). In order to extract the square root of the differential with a bell type instrument, a formed bell may be used as in (*s*). A uniform scale is thus achieved. Another method of extracting the square root with a bell type instrument is shown in (*t*) (Bailey). This, for lower differential pressures, uses a formed displacer in a mercury well to give a variable counterbalancing to the bell. Still another manometer, shown in sketch (*u*), is of the tilting type in which the manometer is suspended on a pivot, tipping in proportion to the differential. This type can be made to tilt in proportion to the flow rate rather than the differential by the addition of a shaped cam bearing against a weighted tape (Cochrane).

Slack diaphragm units are also used for the measurement of small differentials. The type shown in (*v*) has a novel spring counterbalancing method which makes the deflection of the diaphragm and pointer proportional to the flow rate (Hays). Although there have been a number of bellows type differential units on the market in the past, the present urge to conserve mercury is responsible for the development of still another (Taylor) which is diagrammed approximately in sketch (*w*). The bellows is calibrated by means of a spring. Its motion is transmitted by linkages which avoid angularity effects to a torque tube which eliminates the stuffing box.

The final type of head meter to be considered is the V-notch weir which is sometimes used for the measurement of open-channel flow rates. The design shown in Fig. 3 (*x*), employing shaped displacers (Bailey) which are positioned by buoyancy rather than by floating, gives a pointer position directly proportional to the flow rate and a uniform scale.

Where a head meter employs a constant opening for the flow and produces a differential pressure related to the flow, area meters maintain a constant differential, varying the orifice with the flow rate. The most important type of area meter is the rotameter in which the float, sketch (*y*), assumes a position approximately in proportion to the flow rate. The type shown in the sketch uses a rotating bob to produce the variable orifice, but having considerable bob surface exposed to the flowing fluid, this type rides at a level which varies with viscosity and must be calibrated for the particular fluid handled. The new Ultra-Stabl-Vis bob (Fischer & Porter) practically eliminates the effect of viscosity by use of a guided bob, as shown in sketch (*z*), which has a sharp-edged "umbrella" at the bottom. Several other types of head meter are also in use, for example, the type shown in sketch (*aa*) of Fig. 3 which has a tapered plug rising in an orifice. Piston and gate types of variable-orifice meters are also used.

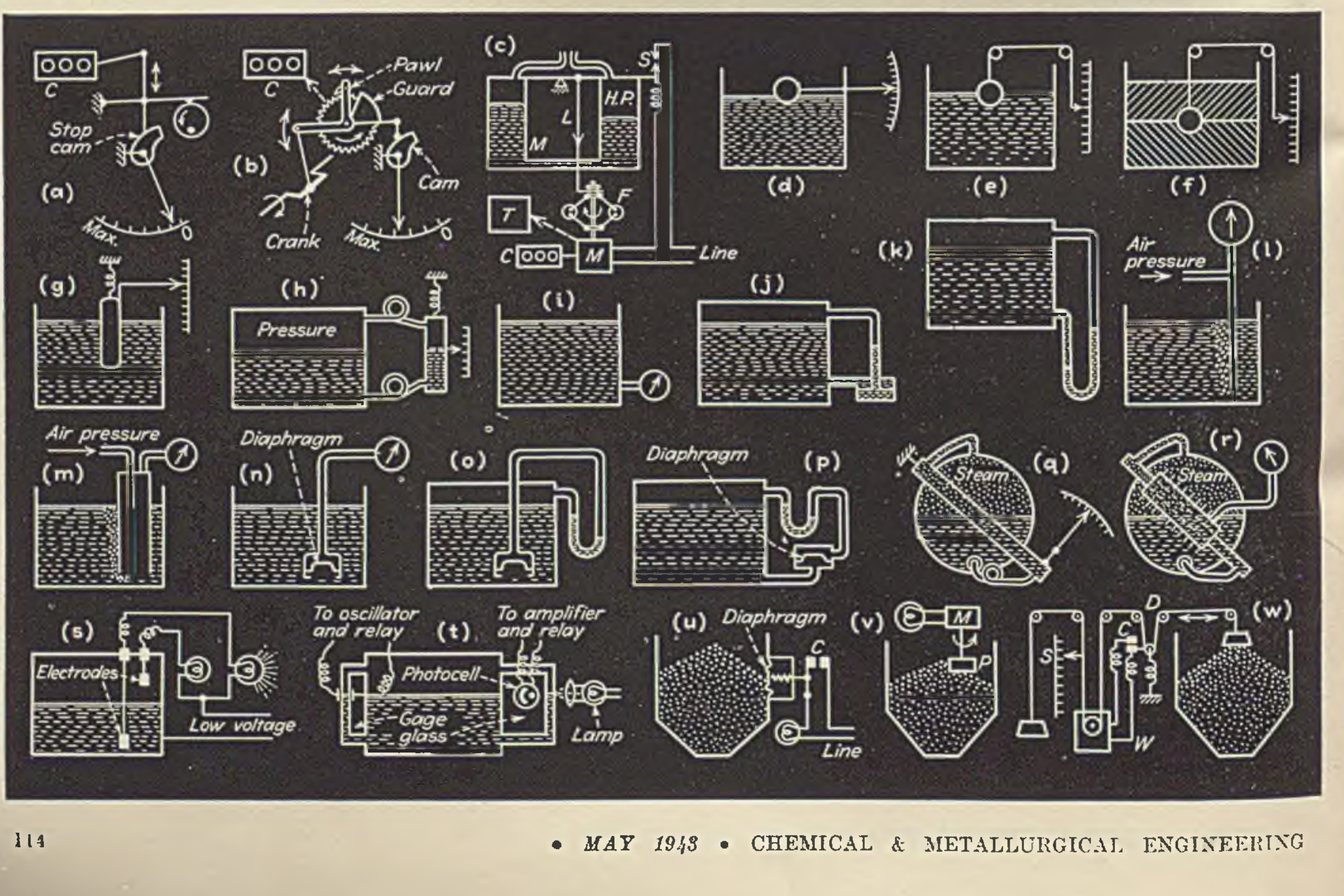
Medium to large flows are often handled with current meters in which the energy of the flowing stream is used to rotate some type of propeller or turbine at a rate directly proportional to the flow rate. The simplest type is the cup anemometer used in meteorology. One type of current meter, sketch (*bb*), which is often used for steam and gases is the shunt meter (Builders Iron Foundry) in which a proportional part of the flow is forced through a shunt around an orifice, being measured in terms of the whole flow by means of a small propeller which drives a counter through a magnetic transmission and hydraulic drag.

The so-called method of mixtures can also be used for flow measurement, that is, energy or some detectable substance can be added in known amount to a flow of material, and its concentration analyzed for downstream. Practically, the only device applying this principle industrially is the energy-adding meter (Cutler-Hammer) which is used in the gas industry. As shown in sketch (*cc*) this meter adds electric heat to the flowing gas to give a fixed temperature rise between resistance thermometers T_1 and T_2 recording the energy added in terms of the amount of flow.

Fig. 4 (*a*) to (*c*) shows a number of methods of flow rate integration. Sketch (*a*) shows a simple integrator in which a square root extracting cam positioned by the manometer float limits the motion of a reciprocating link which drives a counter *C* through a ratchet. Sketch (*b*) illustrates diagrammatically a common type of integrator having a movable guard over a ratchet wheel which is positioned by a square root cam to limit the motion of an oscillating pawl which drives the ratchet wheel. The number of teeth by which the ratchet is advanced each oscillation thus becomes proportional to the flow rate. The wheel drives a counter *C*. Another principle of square root extraction which makes possible a simple method of integration has recently appeared in two modifications. That shown in sketch (*c*) employs a flyball governor (Leeds & Northrup) while another type employs a gyroscope. Gyroscopes and flyball governors give a force proportional to the square of their speed and so can be used to balance a differential pressure, which itself is proportional to the square of the flow rate. The manometer in sketch (*c*), designated as *M*, is a tilting type, maintained level by the force of flyball governor *F* which is driven by a motor. When the manometer tilts down to the left, contact *S* energizes the motor which increases the flyball speed until link *L* has restored the balance and opened the contact. Thus the motor alternately speeds up and slows down, maintaining a speed closely proportional to the flow rate. A counter *C* totalizes the motor revolutions in terms of flow, while a tachometer *T* operates a flow rate indicator or recorder.

(*b*) *Liquid Level*—Liquid level is measured both by direct and by infer-

Fig. 4 Sketches (a) to (c) typical flow meter integrators; sketches (d) to (w), level-measuring methods



ential means. The first class includes the gage stick and gage glass, floats and buoyancy-type displaces, and the method of weighing a small floating tank containing liquid at the same level as the main tank. Among the inferential methods is the common one of measuring the hydrostatic head of the liquid above a suitable reference point; and an inferential method used in boilers which depends on the difference in temperature between the steam and the water in the boiler drum. Float measurement is often the simplest type for small or medium ranges of level fluctuation, or for control. For wide fluctuations, the hydrostatic pressure head of liquid at a suitable reference point is usually measured, either directly by any suitable type of pressure responsive mechanism, or indirectly, by measuring the pressure of an air column of equivalent pressure head.

Sketches (*d*) to (*f*) of Fig. 4 show float methods. Sketch (*d*) shows a simple float and pointer, and (*e*) a simple float, rope and pulley indicator. Sketch (*f*) illustrates interface level indication with a float which floats on the heavier of two immiscible liquids, and sinks in the lighter. Interface level can also be indicated by the buoyancy type level indicator illustrated in sketch (*g*). In this last sketch, a displacer counterbalanced by a spring rises not with the level, but by an amount proportional to the level changes. Depending on spring and displacer characteristics, any desired range of level variations can be handled with a small change in displacer position. Sketch (*h*) illustrates a method frequently used with vessels under pressure. A small spring-counterbalanced weigh tank connected flexibly to the main tank indicates by its level a quantity proportional to the main tank level.

Hydrostatic pressure methods are illustrated in sketches (*i*) to (*p*) of Fig. 4. In sketch (*i*) the hydrostatic head is measured directly in terms of level in an open tank by means of a pressure gage at the reference point. In a closed system under pressure, a differential-pressure manometer can be used to give a reading proportional to the level. As shown in sketch (*j*) the manometer is placed at the reference point. However, the manometer can be placed below the tank as in sketch (*k*) but the extra head thus introduced thus must be allowed for. Another way of getting at the hydrostatic head, as shown in sketch (*l*), is to measure the pressure necessary to force air down a pipe until it bubbles from the bottom at the desired reference point. A variation of this idea often used for corrosive liquids is shown in sketch (*m*). Frequently, instead of bubbling air into the tank, a closed bell with a flexible diaphragm is used to apply pressure equal to the hydrostatic pressure at the reference point to the air inside a closed system. This is shown in sketch (*n*), while sketch (*o*) shows the same method applied to a pressure tank. If the diaphragm bell must be outside the tank, the arrangement of sketch (*p*) can be used.

It was mentioned that a differential-temperature method of level measurement can be used in boiler drums. Three types are employed, principally for level control, rather than measurement alone. The first type, illustrated in Fig. 4 (*q*) employs a tube connected at its top and bottom to the upper and lower part of the boiler drum. Changes in the length of the tube, which varies as its average temperature, are used to position a boiler feed valve. Another variation of this scheme is to employ a small steam generating jacket around the first tube, containing water which is more or less vaporized depending upon the relation between steam space and water space in the inner tube. Pressure in the small generator can be used to operate a pressure gage or position a boiler feed valve. This arrangement is shown in sketch (*r*). A third method measures the average tube temperature by a series of thermocouples.

Several electrical methods of level measurement are also available, but are used chiefly for level control at one point or between two points without intermediate measurement. The first, shown in sketch (*s*), Fig. 4, employs electrodes to detect the level in a conducting liquid. With an electronic amplifier the level of liquids of negligible conduction can be detected. Sketch (*t*) shows an electronic method using condenser plates connected into an electronic oscillator circuit, and arranged either side of a gage glass. When water rises between the plates their capacity is changed. This causes the oscillator to operate a relay to start or stop a pump, or light indicating lights. A second method accomplishing the same result is to use a photocell illuminated by a light source placed on the far side of the gage glass, also shown in (*t*).

Several methods have been developed for measuring the level of solids stored in bins. One method (Bindicator) is shown in sketch (*u*) of Fig. 4. A flexible diaphragm mounted in the side of the bin wall operates contacts *C* when material rests against the diaphragm. Another solids level detector (Fuller), shown in sketch (*v*), uses a rotating paddle *P* driven by a motor. When the solids rise high enough to stop the paddle, the motor *M* rotates about its shaft and closes a contact to light a signal light. These methods require an indicator at every level at which height of the material is to be detected. A third method (Dracco), shown in sketch (*w*), gives a semi-continuous indication of level at any point in the bin. By a system of cables and pulleys, a weight is moved upward and downward by a winch *W*. When the weight strikes bottom a slack detector *D* opens contact *C*, stopping the winch which, after a time delay, pulls the weight to the top, and again lowers it. The points at which the pointer reverses on scale *S* represent the succession of levels of material.

(*c*) *Weighing*—Weighing of materials is always accomplished directly by balancing the gravitational force exerted by the mass of the material against a known force, either that produced by a known-weight, or by the pull of a spring. Liquids at rest are often measured by weighing, although flow meters are always used for the measurement of liquid flow rates. Solids however, may be weighed in motion. Continuous systems for solids measurement all operate by weighing the material present at each instant on a section of moving conveyor, the speed of which is known. For flow rate control the quantity deposited in a unit time on the weighing section of the conveyor can be controlled by the weighing mechanism. Semi-continuous flow rate control of both liquids and solids is sometimes obtained by the automatic weighing of definite increments of material, followed by automatic discharge when the desired weight has accumulated in the weigh hopper or tank.

Sketches (*a*) to (*l*) of Fig. 5 illustrate a variety of weighing methods. Sketch (*a*) shows an even-balance scale of classical type, while sketch (*b*) shows the uneven-balance, or steelyard, which was an early development of the even-balance type, enabling the use of a poise of less weight than the object weighed. Sketch (*c*) is a diagrammatic representation of the lever and beam system of a platform scale. A system similar to this is used in practically all large-capacity scales. The one important variation is to use a pendulum rather than a movable poise on a beam as the balancing mechanism.

Few industrial scales employ spring counterbalancing, as illustrated in the simple scale of sketch (*d*). One type (Chatillon) employs carefully calibrated springs, but most types employ either a movable poise on a beam or the pendulum system mentioned.

Sketch (*e*) of Fig. 5 shows a semi-continuous hopper scale for lump or granular solids. The scale-balanced hopper moves a scale beam which makes or breaks contact, controlling a feeder conveyor. When the set weight is reached in the hopper, the feeder stops, the hopper bottom opens, discharges and closes, and the cycle repeats, recording the number of cycles on a counter. Instead of a weigh hopper, another semi-continuous automatic scale or batcher (Richardson) uses a weigh belt. The weigh belt is carried on the scale mechanism and runs continuously, but is fed intermittently under control of the scale by means of an intermittent feeder belt. A third variation of the semi-continuous method is illustrated in sketch (*g*). Here a scale-balanced weigh tank for liquids closes an inlet valve and opens a discharge valve when a predetermined weight has been reached, then repeats the filling and emptying cycle, recording the number of cycles.

Sketch (*h*) of Fig. 5 is illustrative of the continuous type conveyor scale of which there are numerous variations. Such scales are either balanced by calibrated springs, or have a poise-moving device operated either mechanically, or by means of contacts and a reversing motor. The latter method is similar to that portrayed in Fig. 2 (*s*). In all such scales a section of conveyor belt is supported by the scale. Many ingenious integrators have been devised to take into account both the instantaneous poise position, and the conveyor speed.

Several continuous weighing feeders

for solids have been developed. Sketch (*i*) of Fig. 5 shows the tilting-belt constant weight feeder (Hardinge) in which the entire feeder belt, which runs continuously, is counterbalanced, and by its position controls the opening and closing of a feed gate. A somewhat similar method appears in the Poidometer (Schaffer) which uses a scale-balanced section of the feeder belt to position a gate at the hopper discharge so as to give constant belt loading.

Vibrating feeders are being employed extensively both with and without weighing attachments for assuring a constant delivery rate. A mechanical method is illustrated in Fig. 5 (*k*) and an electrical method in sketch (*l*) In sketch (*k*) (Omega Machine Co.) a continuously running scale-balanced feed belt is fed by a mechanically vibrated conveyor, the amplitude of which depends on the feed rate desired. This amplitude is adjusted continuously by means of a resilient wedge hung from the weigh beam, which is interposed between two jaw plates, one attached to a rapid reciprocating mechanism, and the other to the vibrating feed trough. The method illustrated in sketch (*l*) (Jeffrey) uses an electrically vibrated feeder to feed a balanced weigh belt. The belt makes high or low contacts to control the amplitude of the vibrator and maintain a constant weight flow rate.

(*d*) *Thickness* — Occasionally the thickness of material in motion is a process variable that requires measurement or control. Various methods are used depending on the properties of the material. Direct calipering by a fixed and movable measuring element, as in Fig. 5 (*m*) is one method of measuring the thickness of moving sheet material. Another is to pass the material between condenser plates where it acts as the dielectric, its thickness being a function of the indicated capacity of the condenser. Materials can also be weighed in transit for thickness determination, as in the case of the moving sheet of the material in (*n*), provided the width is fairly constant. A number of laboratory methods for thickness measurement are also available including diffraction methods which can be used for extremely thin transparent films and coatings and the magnetic thickness gage for determining the thickness of non-magnetic coatings on magnetic base materials which gives a response proportional to the distance by which the instrument and the magnetic base of the coating are separated.

(*e*) *Speed*—Rotative speeds of various pieces of process equipment often require measurement and usually control. Tachometers for speed measurement operate on both direct and inferential principles. The direct type of instrument which counts the number of revolutions in a given time cannot be used for continuous speed measurement, although an automatic type which would give such indications periodically could be designed if desired. Continuous methods of speed measurement are all inferential.

The most common type is the magneto tachometer illustrated in Fig. 5 (*o*) in which a small d.c. magneto operates a voltmeter calibrated in terms of speed. Other common methods include the magnetic drag type used in automobile speedometers and the flyball governor type illustrated in sketch (*p*). The force is proportional to the square of the speed and this type, therefore, gives a non-uniform scale. Less-used methods depend on the pressure produced by some sort of pump or blower. For example, in sketch (*q*) a small centrifugal pump produces a liquid column head which can be calibrated in terms of rotative speed of the pump. A similar scheme is to use a blower as in (*r*) to draw a liquid column up to a height bearing a calibratable relation to the speed. Another method, sketch (*s*), uses a group of metal reeds of different vibration periods. This type operates simply by contact with the running machine, one or more reeds vibrating visibly at a rate equal to the vibration period of the machine. This method is also used for electric-frequency measurements. When connection of the tachometer with the rotating part cannot be made for any reason, stroboscopes are often used. These operate by use of either a rotating shutter or flashing light with which to view the rotating part. When synchronism or a multiple of synchronism is obtained, the rotating part appears to be stationary, at which point the speed of the shutter or the frequency of the light is measured. Sketch (*t*) illustrates a stroboscope employing a flickering gas-discharge lamp synchronized with the rotating object.

3. COMPOSITION

The variables of this group, having to do with the chemical composition of the material, include:

(*a*) Density and specific gravity
(*b*) Viscosity and consistency
(*c*) Hydrogen ion concentration
(*d*) Electrical conductivity
(*e*) Thermal conductivity
(*f*) Caloric value
(*g*) Explosibility and flammability
(*h*) Humidity
(*i*) Color, opacity, smoke density and turbidity
(*j*) Moisture content
(*k*) The composition itself.

In addition, there are a number of other variables such as hardness, dielectric constant, magnetic susceptibility, specific heat, index of refraction, degree of polarization of transmitted light, decomposition potential, and reflectivity, which are often measured with laboratory type instruments, but seldom with industrial instruments.

Both direct and inferential methods are used in measuring the variables in this group. The methods are so numerous that it will be possible here to describe only the most important principles employed.

(*a*) *Density*—Density of a material is its weight per unit volume while specific gravity is the ratio of its weight per unit volume to the weight per unit volume of a reference substance, both at the same standard temperature. In the case of solids and liquids, the reference substance is water, generally at 60 deg. F.; for gases, the reference substance is air. Specific volume of a substance is the volume per unit weight. Obviously, all of these quantities are interchangeable, and may be discussed in terms of density. The density of a substance at a particular temperature and pressure may be determined directly by weighing a definite volume of the material, or by measuring the buoyant force exerted by the material on a suspended displacer. The most common method for liquids is to measure the volume equal to a definite weight which is generally done by means of a hydrometer, a simple type of displacement instrument.

Sketches (*a*) to (*e*) of Fig. 6 show methods for measuring the density of liquids. In sketch (*a*) the weight of a fixed volume of liquid is determined directly. Sketch (*b*) shows the method of determining liquid density by determining the weight of the liquid displaced by an object suspended on a scale beam. The loss in weight when the object is submerged is the weight of a volume of liquid equal to the volume of the displacer. Sketch (*c*) illustrates the hydrometer which measures directly by displacement that volume of liquid which is equal to the weight of the hydrometer. However, calibration is in terms of density or specific gravity, rather than weight. Sketch (*d*) illustrates an automatic density meter or hydrometer (Bailey) which employs a balanced beam carrying a large volume displacer at one end, balanced against a small volume counterweight at the other. A pendulum regulates the movement for a given change in density. To correct for temperature variations, the large volume displacers contain a sample of the test liquid. Another method of measuring liquid density is to measure the differential pressure produced by two air bubble pipes of different lengths in the liquid. This method (Hays) is illustrated in sketch (*e*). The differential pressure ΔH is proportional to the liquid density.

A variety of methods are available for measurement of gas density. The density of gases may be inferred from the viscous drag produced by a moving or rotating column of the gas, or from the increase in kinetic pressure of the gas between the suction and blade tips of a rotating radial impeller. More commonly, however, some device capable of weighing a column of the gas is used. Gas density measuring devices are shown in Fig. 6 (*f*) to (*i*). Sketch (*f*) shows the Edwards gas density balance in which a scale-balanced displacer inclosed within a box is brought to a balance point as viewed through a window, using a standard gas. The test gas is then passed into the box and its pressure adjusted to give the same buoyancy as indicated by the pointer. The difference in pressure between the standard and test gases as shown by a manometer is then a measure of the difference between their densities. Another method of weighing the gas which operates directly is shown in sketch (*g*). This gas balance (Alpha-Lux) weighs a tall column of gas at atmospheric pressure by means of a floating, liquid-sealed bottom to the test chamber, which is balanced by a scale beam. The viscous drag method of density measurement is found in the Ranarex instrument (Permutit) shown in sketch (*h*). The instrument has two chambers, one containing the standard gas, with the test gas flowing through the other. In each chamber are two paddles; the rear paddles are driven in opposite directions at the same speed by a motor. The whirling column of gas in each chamber tends to rotate the front paddles which are tied together by a linkage, so that the balance point is a measure of the relative density of the two gases. This method is frequently used for gas composition determination.

Sketch (*i*) of Fig. 6, shows the Metric Gravitometer which measures gas density in terms of the increase in static pressure as the gas passes from the center to the blade tips of a fan. Air is sealed under standard conditions in the left-hand chamber. The flexible diaphragm controls a reducing valve to admit test gas at the same pressure as the standard gas at the existing temperature. The test gas flows continuously through the instrument, the issuing jet being ignited. Test gas is drawn into a fan, the pressures at the fan inlet and blade tip being measured by a liquid-sealed bell manometer.

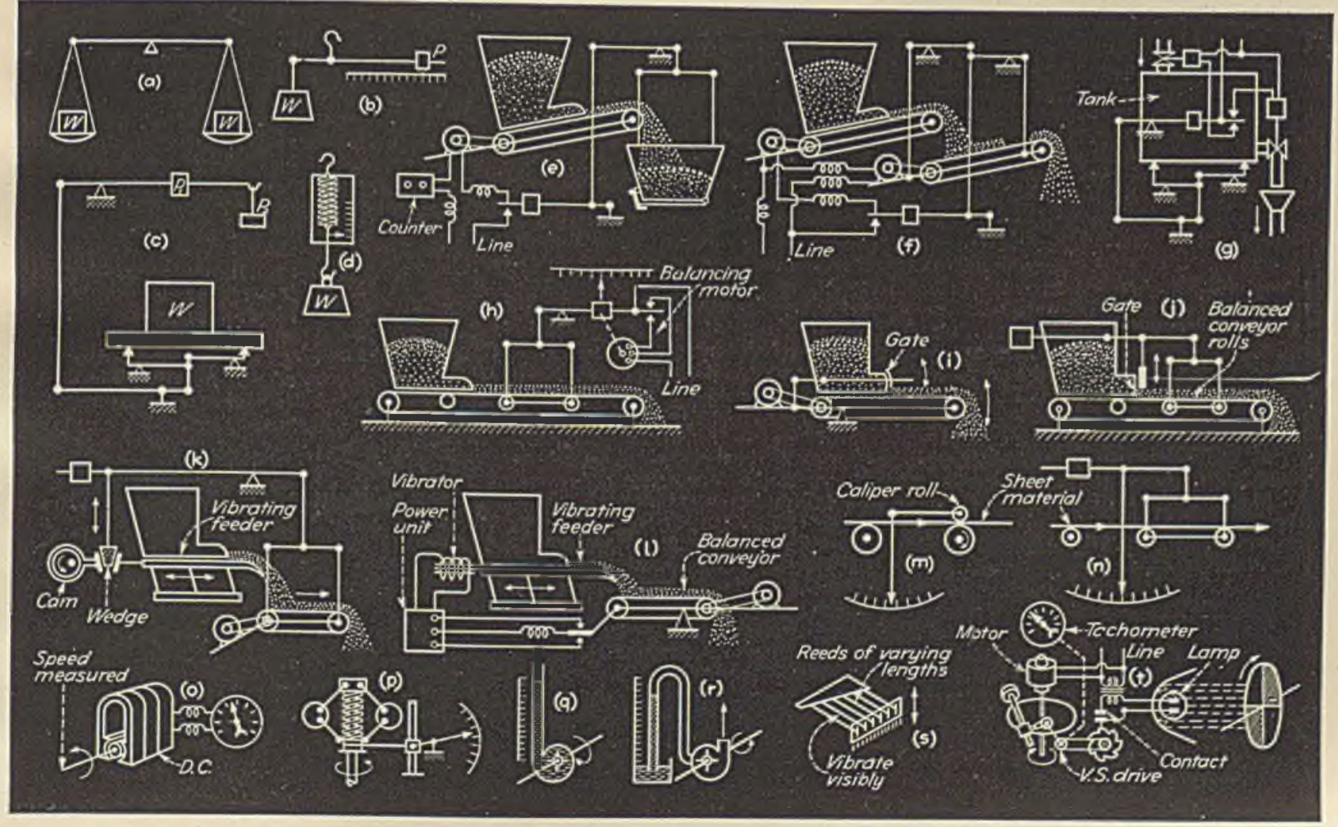
(*b*) *Viscosity*—Viscosity is a measure of the force required to shear a fluid at unit rate. Consistency is a property related to viscosity or plasticity which is encountered in the case of suspensions, such as paper pulp. Suspensions do not exhibit true viscosity, but the consistency can be measured by methods similar to those used for viscosity. Viscosity (or consistency) can be measured by determining the torque required to rotate a paddle or cylinder in the material, or by measuring the rotative speed of a paddle or cylinder driven by a known torque. Other methods include timing the flow of a definite quantity through a short tube or a capillary, measuring the pressure drop through a capillary, or in the case of liquids, timing the rise of an air bubble through the liquid or timing the fall of a ball or other object.

Examples of viscosity and consistency measuring devices appear in Fig. 6 (*j*) to (*o*). In sketch (*j*) a paddle rotated in a liquid at a known speed by a known force measures viscosity. However, viscosity is often determined by measuring the time required for a definite quantity of flow through a short tube, as in (*k*), which is the method employed in most viscosimeters, such as the Saybolt and Engler. For continuous measurement of viscosity the method of (*l*) is commonly used, by measurement of the pressure drop in a material flowing at a known rate through a friction tube. Sketch (*m*) illustrates the rising bubble and falling ball methods which are particularly adaptable to extremely viscous materials. Consistency measuring methods are most important in the paper industry where they are generally employed for automatic control. One such method, sketch (*n*), measures the torque required to drive a paddle in a paper stock suspension in terms of the tension in the tight side of a belt or chain drive. The tension is used to adjust the position of a water dilution valve. Another way to measure paper stock consistency is to measure the slope of the stock as it flows in a trough. The Brammer consistency controller (Paper and Industrial Appliances) does this by measuring the differential pressure in two air bubble pipes, as in sketch (*o*). The ratio of ΔP to L is a measure of the consistency. The differential pressure can readily be applied to control.

(*c*) *Hydrogen Ion Concentration*—Hydrogen ion concentration can be determined by two methods; an inferential colorimetric method using indicator solutions which respond by color changes to changes in pH; or a direct electrometric method whereby the electrical potential produced by a special cell in contact with the liquid is measured in terms of concentration of hydrogen ions in the liquid.

The first method is carried out with some variation of the unit sketched in Fig. 6 (*f*). This is a block comparator. Standard color tubes are placed in the front row, and sample tubes in the back row. They are then compared visually against a suitable light through the horizontal slots. The arrangement is as follows: tube 1 contains a standard color corresponding to some definite pH; tube 2, distilled water; tube 3, a standard color for the next higher pH; tube 4 contains a sample of the test mate-

Fig. 5—Sketches (*a*) to (*l*), weighing methods and feeders; (*m*) and (*n*), thickness measuring devices; (*o*) to (*t*), speed measuring devices illustrating several different principles



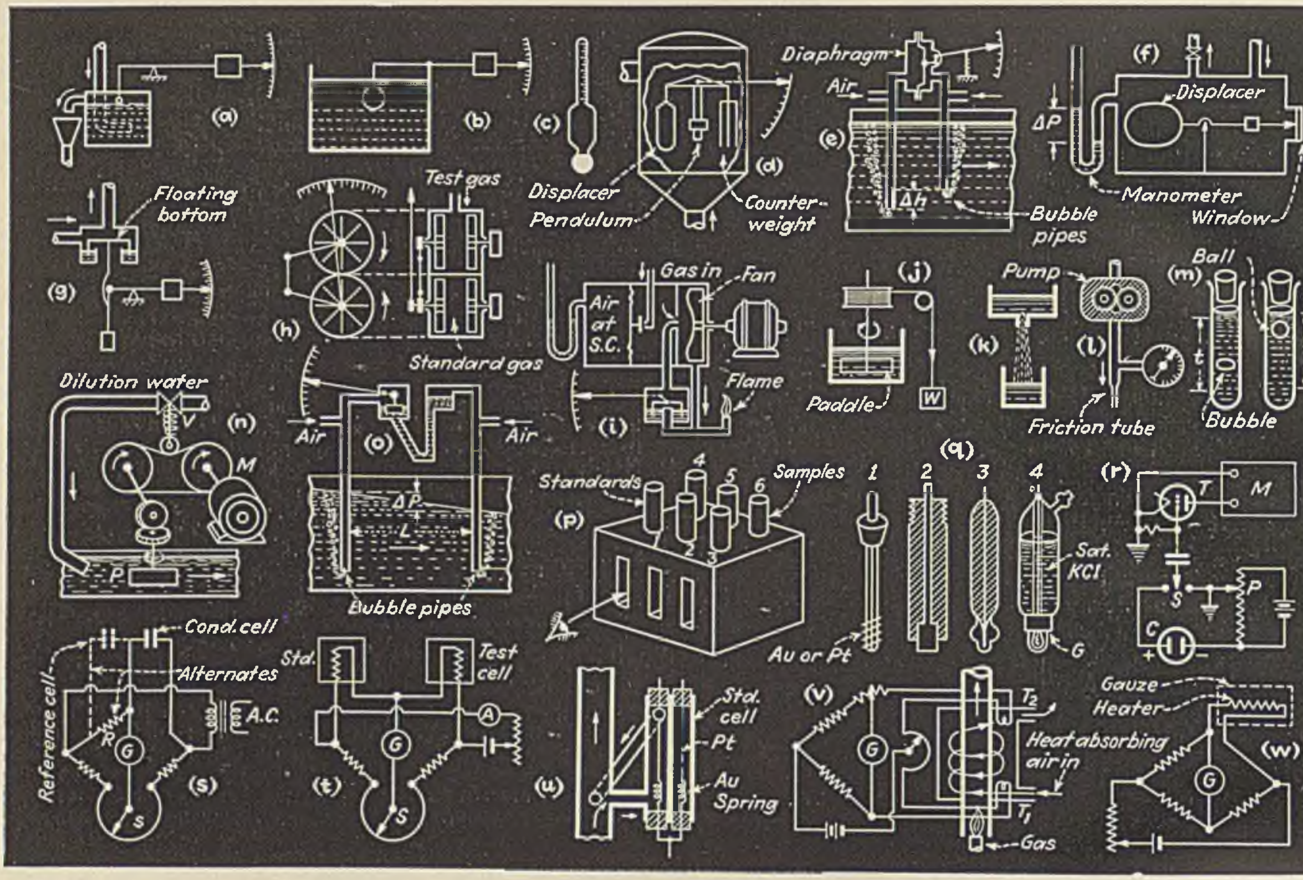


Fig. 6—Sketches (a) to (i), density measuring methods; (j) to (o), viscosity and consistency; (p) to (w), pH, electrical conductivity, calorific value and explosibility measuring devices

rial; tube 5 a sample of the test material plus its indicator; and tube 6 a sample of the test material. The different standards are placed in positions (1) and (3) until a match or close match with tube 5 is obtained.

Electrometric methods of pH measurement are based on the fundamental hydrogen electrode which, on account of difficulties in use, is seldom used except in precise laboratory work. The method is based on the fact that an electrode immersed in a solution containing ions will generate a potential proportional to the concentration of hydrogen ions. It is not possible to measure the potential of a single electrode so that a standard electrode of known potential must also be used. The potential produced by the test electrode and the standard half cell will then be the algebraic sum of the two half cells and this potential can be measured by a potentiometer in terms of hydrogen ion concentration. Three types of measuring electrode are employed, the quinhydrone, the antimony, and the glass electrode. Fig. 6 (*q*) shows typical forms of these electrodes. At (1) the quinhydrone electrode uses a fine gold or platinum wire serving as an inert metal contact, but "quinhydrone" a combination of quinone and hydroquinone must be added to the solution under test. The antimony electrode (2) consists of an antimony plug molded in insulation. In this case nothing need be added to the solution, and this method is frequently used for industrial work. Its usual range is from pH4 to pH11. The electrode is of low resistance and, therefore, does not require extreme instrument sensitivity. At present the most used type of electrode is the glass electrode shown in (3), which consists of a thin bulb of glass containing a silver electrode immersed in silver chloride solution. This electrode is a high resistance type requiring the use of special electronic methods of amplification for measurement. Improved glasses are now available extending the range of this electrode all the way from pH 0 to pH 14. All types of electrodes are used in conjunction with some form of standard calomel reference electrode. This electrode, shown in (4), contains saturated potassium chloride solution in the outer tube with mercury and HgCl in the inner tube. It is necessary to form an electrical contact between the potassium chloride solution and the test solution without mixing, and this is generally accomplished by means of a ground joint as shown at *G*, or by means of a capillary leak. Various electronic measuring hook-ups have been developed for glass electrode use. One type is shown in Fig. 6 (*r*), a hook-up designed to avoid the effect of grid current error. An amplifying tube *T* and meter *M* are used to determine when the potentiometer *P* is adjusted to the voltage produced by cell *C*, which consists of a glass electrode and a calomel reference electrode. The circuit is operated by throwing switch *S* to determine if the cell is at ground potential. When the potentiometer is properly adjusted no galvanometer throw is obtained.

(*d*) *Electrical Conductivity*—Electrical conductivity of solutions is used as a means of determining the concentration of single electrolytes and also in a variety of alarm systems for determining leakage of electrolytes into condenser water, etc.

A typical arrangement is shown in Fig. 6 (*s*). A conductivity cell consisting of two inert electrodes is placed in the solution under test. This cell is connected in a wheatstone bridge circuit operated on alternating current to avoid polarization of the electrodes. Instead of resistance *R*, a reference cell containing a sample of the liquid of desired concentration can be suspended in the test liquid, but not allowed to mix with it, in order that changes in resistance of the liquid due to temperature may be compensated for. Simple conductivity bridges frequently employ a cathode ray null indicator for bridge balancing instead of a galvanometer.

(*e*) *Thermal Conductivity*—One of the most used methods of analyzing gas mixtures is to measure the thermal conductivity. The method measures the change in resistance of a heated wire due to the heat lost from the wire through the surrounding atmosphere of test gas.

In Fig. 6 (*t*) is shown a typical thermal conductivity hook-up. This method employs a pair of thermal conductivity cells, one containing a standard gas, the other the test gas. The comparative rate of heat loss from the heated platinum wires of the two cells is a measure of the relative thermal conductivity of these two gases. The method requires calibration for the type of gas mixture tested, and is generally suitable only where the various components of the mixture differ considerably in thermal conductivity. However, it is sometimes possible to separate such components chemically or alter them so as to permit analysis. For example, carbon monoxide has nearly the same thermal conductivity as air, but carbon dioxide differs considerably from air. To analyze a mixture of carbon dioxide, carbon monoxide and air (Cambridge), the mixture is first passed through one of the two conductivity cells where the concentration of carbon dioxide is measured in terms of resistance change, after which the mixture is passed over a heated carbon rod to burn the carbon monoxide to carbon dioxide. The mixture is then passed through the second cell and the analysis determined in terms of the comparison of conductivities in the two cells. Sketch (*u*) shows a typical arrangement of standard and test cells for a flowing sample.

(*f*) *Calorific Value*—Calorific value of combustible materials is determined by burning the material and transferring the heat to a material of known specific heat, such as water or air, after which the temperature rise of the heat absorbing material is measured.

A typical gas calorimeter (Cutler-Hammer) is illustrated in Fig. 6 (*v*). Here the test gas is metered and mixed with a metered volume of combustion air and is then burned inside a heat exchange tube where it transfers its heat to a known volume of heat absorbing air. The temperature rise of the heat absorbing air is measured by two resistance thermometers T_1 and T_2 connected into a wheatstone bridge circuit. A self-balancing galvanometer is used to bring the bridge circuit to balance, the slidewire position being a measure of the temperature difference between the thermometers and hence of the calorific value.

(*g*) *Combustible Gases*—Closely related to the automatic calorimeters of group (*f*) are the instruments for the detection of hazardous concentrations of combustible gases. They are, however, also related to the thermal conductivity analyzer. For example, Fig. 6 (*w*) shows the circuit for such a detector in which a heated platinum wire inclosed in a safety screen of metal gauze burns any combustible gas that may be present. The increase in temperature of the heated platinum filament is then measured in terms of the change of its resistance, calibrated in concentration of the combustible gas. In such instruments a wheatstone bridge circuit of the deflection (unbalanced) type is employed.

(*h*) *Humidity*—Humidity is a term generally taken to mean some function of the concentration of water vapor in air. It is also being applied today in expressing the concentration of other vapors in air, or in other gases. Humidity may be determined directly by ad- or absorption, or by several inferential methods, although the latter are almost always used in practice. For example, change in the dimensions of various hygroscopic organic materials is an important method of measuring humidity. Somewhat similar is the method developed by the U. S. Bureau of Standards for measuring the electrical conductivity of a hygroscopic salt. The relation between the temperature of the air and the temperature of a water-wetted wick which has fallen to the adiabatic saturation temperature* in the air stream is probably the most important method used industrially. Another inferential method is to determine the temperature at which the moisture in a particular sample of air begins to condense on a cold surface. This is the so-called dewpoint method. Measurements obtained by any of these methods may be interpreted in terms of relative, absolute or percentage absolute humidity.

Sketches of Fig. 7 (*a*) to (*g*) show various methods of humidity determination. Sketch (*a*) shows a spiral coil hygrometer similar in appearance and principle to a bimetallic thermometer. It is composed of a strip of wood shaving or other hygroscopic material cemented to a thin metal strip or screen having the desired spring characteristics. Changes in dimension of the hygroscopic material cause the coil to unwind for higher humidity or wind for lower humidity. The device reads direct in relative humidity. Sketch (*b*) shows the commonly employed method of using human hair or animal membrane for the direct measurement of relative humidity. A third method using a hygroscopic material is shown in sketch (*c*) where wood blocks cut across the grain are used, their dimensional change being amplified for measurement or control. Sketch (*d*) shows a sling pyschrometer which is the simplest form of wet- and dry-bulb thermometer capable of giving reliable results. The pyschrometer is whirled by means of a handle to produce the desired velocity of air past the wick-inclosed wet-bulb thermometer. The moisture content of the air can be read direct from a psychrometric chart, given the dry-bulb temperature and the wet-bulb depression. The same method is employed in indicating and recording instruments as diagrammed in sketch (*e*). Here an air stream is forced over the wet- and dry-bulb thermometers at a rate sufficient to assure the maximum possible wet-bulb depression for the existing humidity. The thermometers shown are of the pressure-spring type and are customarily arranged to indicate or record on the same scale.

A different principle in hygroscopic measurement appears in Fig. 7 (*f*) which illustrates an instrument developed by the U. S. Bureau of Standards. Here a double coil *H* of palladium wire is wound on an insulating core, the wires being coated with a film of hygroscopic lithium chloride suspended in a water-soluble coating. The electrical conductivity of the coating then varies with the relative humidity and is measured by a microammeter *M*, provided with a.c. energy through a transformer *T* and a full-wave copper-oxide rectifier *R*. To secure a long range, several such sensitive elements must be used in series, each differing in overall resistance from the others.

Sketch (*g*) of Fig. 7 illustrates a recording dewpoint meter developed by the Colorado Interstate Gas Co. for measuring the dewpoint of fuel gas in cold weather to prevent freeze-ups. The device illustrates the principle of other dewpoint measuring instruments and is suitable for automatic operation on any gas-vapor mixture. The gas passes through a duct having a polished interior, flowing past mirrors *M*. The duct is heated or cooled by an anti-freeze bath equipped with a heater *H* and a cooling coil *C*. Uniform temperature is assured by a stirrer *S*. A beam of light from an incandescent bulb *I* is passed through the duct to photocell *P*. Formation of dew reduces the light transmission which is detected by amplifier relay *A*. The relay energizes the heater until the dew has disappeared. Then the refrigeration unit starts again and cools the bath. The record of temperature is a succession of peaks and valleys, the latter showing the successive dewpoints.

(*i*) *Color*—Color, opacity, smoke density and turbidity are factors which can be measured directly in comparison with a standard, or measured photoelectrically. The first factor, color, may be determined roughly by visual comparison with one or more standard colors, or accurately, by measuring the intensity of reflected or transmitted light of various wavelengths, compared with the transmission or reflection of a standard. Instruments for complete color analyses make use of a spectrometer to produce monochromatic light of any desired wavelength which can be passed through the sample cell to illuminate a photoelectric cell.

In sketch (*h*) of Fig. 7 an incandescent light source *I* produces light which is collimated, split in a prism and reflected by a movable mirror *M* on to a slit *S*. The wavelength of monochromatic light passing through the slit is determined by the angle of the mirror, which is indicated on wavelength scale *W*. The monochromatic light is passed through the material, or reflected from it, and tha transmission or reflection measured by photocell *P*, in collaboration with meter *M*. The procedure in making a color analysis is to determine the intensity of transmission or reflection at each of several wavelengths. A curve of the successive intensities plotted against wavelength is then a true record of the color response of the substance. Various devices have been developed for making such color analyses automatically.

* Note that the temperature of the wet bulb is not actually the adiabatic saturation temperature, although in the case of air and water vapor, it is nearly so and the discrepancy is unimportant. The wet-bulb depression method of humidity measurement is inapplicable to other mixtures of gas vapors, unless true adiabatic saturation is obtained in an insulated saturator. For such mixtures, it is generally better to use absorption or dewpoint methods.

A similar instrument, known as a color comparator, is used to achieve a satisfactory visual match between two colors by comparing the test material and a standard successively under white, red, green and blue light. One type (Westinghouse) is shown in sketch (*i*), Fig. 7. The intensities of reflected light from the sample and from the standard *S* are compared by photocell *P* under the different colors, using color filter *F*. The mirror *M* reflects the light on to the sample (or standard), which is then reflected diffusely from a white diffusing surface inside the inclosure on to the photocell *P*.

Smoke and fume detectors, as illustrated in sketch (*j*), employ a beam of light traversing a duct or chimney from incandescent filament *I*, through a lens system and windows, to a photocell *P*, where the decrease in light transmission due to the smoke or fume is registered by meter *M*.

(*j*) *Moisture Content*—Moisture content of solids can be measured in various ways in addition to the fundamental method of weighing and drying. Probably the commonest method is to measure the electrical conductivity. In the case of crystals or powdered materials it is necessary to insure a standard density of material before making the measurement. Measuring the humidity of air in contact with the substance is another useful method.

(*k*) *Automatic Analysis*—One characteristic of several of the variables in the group just discussed is that they are often measured, not for themselves, but as a measure of some other process variable such as the composition, concentration or "quality" of the material. Many methods are employed for the automatic and semi-automatic determination of composition, including many automatic gas analyzers. The automatic orsat type analyzer is frequently used for determining one or two constitutents in a gas by the absorption of each constituent separately, and the subsequent measure of the resulting drop in pressure.

Fig. 7 (*k*) shows one type of automatic orsat for carbon dioxide measurement (Republic). This device employs a power driven piston to achieve the measuring cycle whereas others generally use water pressure. Flue gas enters at *A*, after being filtered and dried (or saturated), part of the flow passing to the apparatus. Piston *B* draws in the sample and forces it through the absorption system by rise or fall of oil moved by the piston. In the position shown, a sample has been drawn into measuring chamber *C*. The piston moves down, raising the oil level in *C* and *H*, trapping the sample in *C* at a measured volume and at atmospheric pressure, then pushing it through pipe *D* into the caustic potash tank *E*, under a baffle. The carbon dioxide is absorbed and the remaining gas rises into liquid-sealed bell *F*, which rises to a height depending on the volume *C*, less the carbon dioxide absorbed. The piston then rises, drawing the spent gas through pipe *G* into *H* where the next cycle expels it. At the same time a new sample is drawn into *C* and the cycle repeats.

A simple type of carbon dioxide meter uses a solid potassium hydroxide absorbent for the gas in measuring burette *B* of Fig. 7 (*l*). The content of carbon dioxide is determined by measuring the differential pressure above and below restrictions *R*.

Under favorable circumstances the composition of a mixture of gases can be determined by measuring the density, viscosity, thermal conductivity or calorific value of the mixture. Similarly, under favorable circumstances, the composition of liquid mixtures can be determined by the measurement of hydrogen ion concentration, electrical conductivity or density. The composition of two-component pulps and suspensions can be determined by density or by consistency.

A number of methods of essentially laboratory character are also being used in increasing extent for production control purposes. An example is the well known saccharimeter used in the sugar industry for determining by polarization the percentage of invert sugar in a sucrose sample. Another is the dropping mercury electrode which is being employed for the identification of metallic ions in solution. The mass spectrometer or "atom sorter" is claimed to be finding application in the analysis of gas mixtures, particularly hydrocarbon gases. This device ionizes the atoms and molecules of the gas mixture, separates them on the basis of their angles of deflection as they round a curve under electrostatic acceleration, and finally determines the concentration of each type of ion by measuring the intensity of its charge. Other methods of gas analysis that are coming into prominence are based on spectroscropic methods similar to the color analyzer described above. For example, the infra-red spectrophotometer is being used in analyzing complex gas mixtures in butadiene and aviation gasoline manufacture. Using 18 definite wavelengths of monochromatic light, the instrument automatically determines absorption of light at each wavelength by the sample, and the results so obtained can be compared with a calibration curve for the type of mixture being analyzed. The ultra-violet spectrophotometer which differs from the first mentioned type principally in using the ultra-violet, rather than the infra-red portion of the spectrum, is also being used in analysis, particularly in identification of vitamin concentrations (Natl. Technical Labs.).

It should be mentioned here that several of the variables related to the composition of the material are affected not only by the composition but also by the energy level of the material, that is, by temperature, or pressure, or both. In such cases it is necessary to measure and make corrections also for these other influencing variables.

4. ELECTRICAL VARIABLES

The electrical variables mentioned in this group include:

(*a*) Potential
(*b*) Current
(*c*) Power
(*d*) Resistance.

In addition, it is sometimes necessary to measure and perhaps control other factors. These include capacitance, inductance, power factor, dielectric constant, magnetic susceptibility and current alternation frequency. Since the instruments for measuring these variables are primarily those of the electrical engineer, they are not described in this article except in cases where an electrical quantity is to be measured in connection with the inferential determination of some other variable such as temperature, gas analysis or hydrogen ion concentration.

5. OTHER FUNCTIONS

It was mentioned that many industrial instruments have a variety of functions in addition to measurement and control of process variables. Included are the following headings:

(*a*) Indicating
(*b*) Recording
(*c*) Cycle control and automatic operation
(*d*) Signalling and automatic shutdown
(*e*) Ratio control
(*f*) Telemetering and remote controlling.

(*a, b*) Because the indicating and recording features of industrial instruments are generally familiar to most engineers, they will be mentioned only briefly here. They have been detailed only occasionally at other points in this article. If a variable can be measured and expressed in suitable units, the measuring device can position a pointer on a scale, thus indicating the succession of instantaneous values of the variable. By the same means, it is possible to position a pen on a moving paper chart, or a stylus on a sensitized surface, and thus plot a continuous record of the fluctuations of the variable against time, or, rarely, against some appropriate variable which determines the movement of the chart. Today most recorders use either strip charts (Fig. 7 *m*) or circular charts (Fig. 7 *n*), usually made of paper. Where records are not filed, circular chart instruments may use cleanable plastic charts instead of paper. Recorders may be either single- or multi-record. Two or more different variables may be recorded by separate measuring systems on the same chart, or several records of the same variable, taken at different points in the process, may be recorded on the same chart. This can be done either by separate measuring systems or by the same system which is switched consecutively to each of the several sensitive elements.

(*c*) *Cycle Control*—Since time is invariable, there is considerable question whether process duration is properly a process variable. Consequently, cycle control and other kinds of automatic operation have been grouped

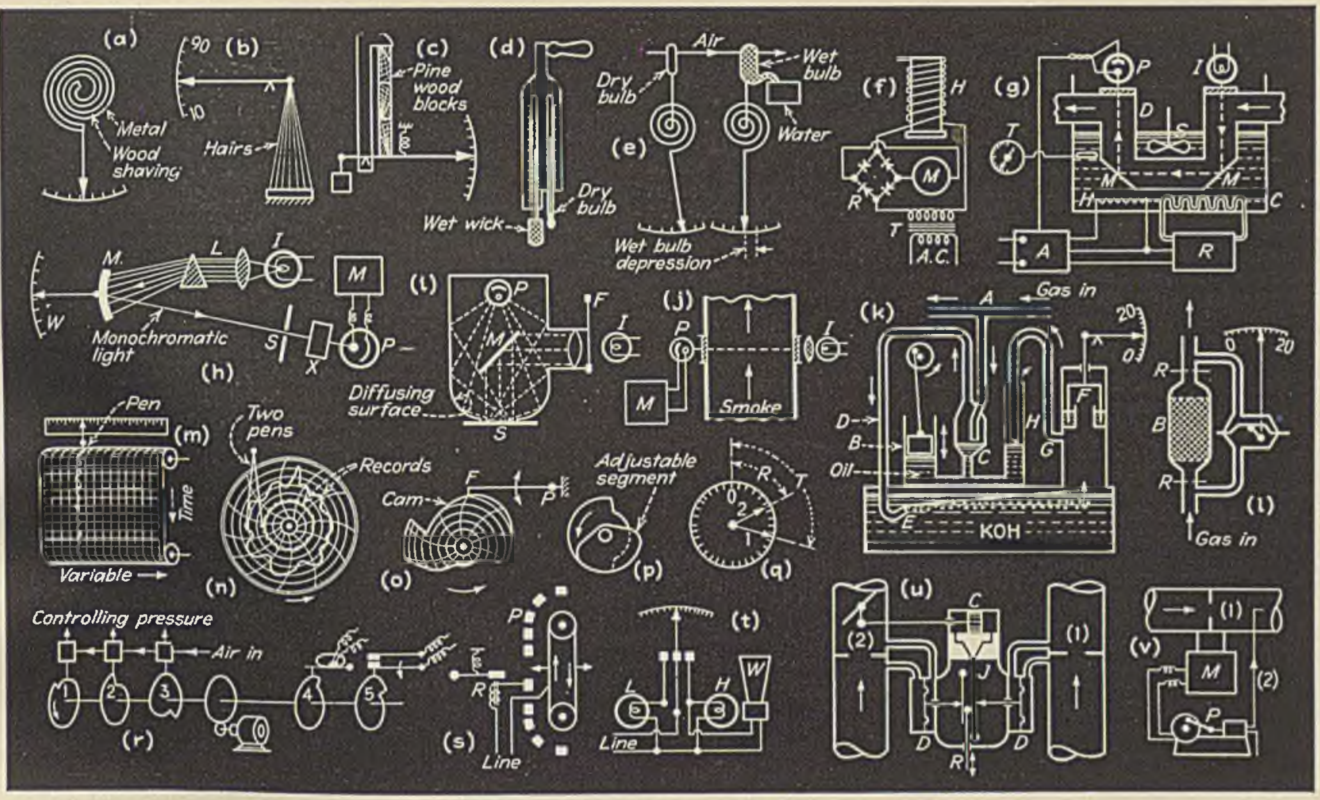


Fig. 7—Sketches (a) to (l), measurements related to composition; (m) to (t), auxiliary instrument functions

with the auxiliary functions of industrial instruments. This group of functions includes duration timing, automatic operation and cycle control.

Cycle control is the automatic changing of the control point of a variable as a function of time. It is usually accomplished as in Fig. 7 (o) by means of a cut cam on which a cam follower *F* rides, continuously resetting the control point at *P*. Frequently it is desirable to use an adjustable cam for this purpose. The type illustrated in sketch (p) is suited only to varying the duration of the low portion of the cam, but adjustable cams have also been developed for varying the rate of change of control point as may be desired.

Interval timing is accomplished by instruments of many types. In the type shown in sketch (q) of Fig. 7 two hands, (1) and (2), move over a stationary dial. Hand 1 is set to the total time *T*, and hand 2 then moves to position (1) and starts the process. It travels counter-clockwise at uniform speed, stopping the process at zero. At any intervening time, a position such as 2 shows the remaining time *R*. After reaching zero, hand 2 may be reset either automatically or manually.

In automatic operation, or programming control, a clock-driven shaft carries a cam for each operation which is to be started and stopped, the cams being cut to give the desired sequence and duration of various operations as in Fig. 7 (r). In this sketch, cams 1, 2 and 3 are shown operating pilot air valves, cam 4 a mercury switch and cam 5 an open-contact switch. The switches and pilot valves can control various circuits and process control valves. By combination of automatic control of the variables of the process and automatic starting and stopping of the various operations, it is often possible to eliminate manual operation entirely, leaving the operator only the task of supervising the instruments.

It has recently been found necessary to control large numbers of valves by automatic operation, which prevents the cam operated apparatus in sketch (r) from being used. Sketch (s), Fig. 7, indicates one method of controlling a great many operations from a single time-function instrument. Here a chain carrying brushes makes contact successively with a large number of contact points arranged at any desired intervals. Each contact point is connected to a relay arranged to open or close a valve or damper.

(d) *Signalling*—In many processes where automatic control of certain variables is not desired, it is still necessary to warn the operator if the variable threatens to go beyond acceptable limits or to assume dangerous proportions. In such case it is a simple matter to provide electrical contacts on the indicating or recording instrument to illuminate lights which show high, intermediate or low values of the variable, to sound a warning signal, or to shut down the process in case of danger. Sketch (t) of Fig. 7 shows the addition of signalling and alarm contacts to an indicating pointer. Here the low contact illuminates light *L*, the high contact light *H*. A warning horn *W* sounds when the high contact is completed.

(e) *Ratio Control*—Another function of industrial instruments which is auxiliary to the measurement and control is ratio control which measures one variable, usually flow, and controls another variable in a desired relation to the first by resetting the control point for the second variable.

Fig. 7 (u) shows an Askania ratio controller. Flow of (1) is measured and adjusts the flow of (2). Swinging jet pipe *J* squirts oil under pressure against adjacent openings communicating with opposite ends of cylinder *C*. Differential diaphragms *D* position the jet pipe. When the flows are at the desired ratio, the jet pipe is centered and the piston does not move. If they are not in proper relation, the jet pipe moves, moving the piston and damper. The ratio is adjusted by vertical movement of the pivot point on the upper end of ratio rod *R*.

Similar methods can be employed with other types of flow controllers. Most types provide a continuously adjustable ratio ranging from zero to as high as 200 or 300 percent. In addition, several other methods of providing one flow in fixed relation to another have been developed for the feeding of comparatively small quantities of chemicals into a larger flow. For example, sketch (v) indicates how a proportioning pump *P* can be paced by a meter which is measuring the primary flow (1). With this arrangement, the meter generally causes one stroke of *P* for every 1, 10 or 100 units of flow (1), thus injecting a definite volume of flow (2).

(f) *Telemetering*—With most types of industrial instruments, except those which measure an electrical quantity proportional to the variable, there is a definite limit to the acceptable distance between the instrument's sensitive element and the indicator, recorder or controller. On the other hand, there is a tendency toward the centralization of indicators and recorders as well as of manual operating controls, which requires that many instruments be farther from their sensitive elements than good practice allows. Without special transmitting means, too much time lag would be introduced, or the primary elements would have insufficient power to transmit the indication with the requisite accuracy.

Numerous telemetering methods have therefore been developed, employing pneumatic, hydraulic and electrical methods. Pneumatic telemeters convert the quantity that is to be transmitted into an accurately proportional pressure which is transmitted to the receiving instrument through a tube of diameter sufficient to avoid undue lag. Hydraulic transmissions, employing an incompressible fluid, displace a certain amount of liquid at the sending end and transmit an equal quantity to the receiver where the quantity transmitted positions the instrument. Electrical telemeters convert the sending impulse into some kind of electrical quantity such as potential, current or frequency.

A newly developed pneumatic telemeter (Republic) is shown in Fig. 8 (*a*). This method balances the force produced by the primary indication directly against a proportional pressure of air which is sent to the receiver. The primary pressure P_1 is applied to diaphragm D_1 and the force applied to a scale beam counterweighted by W_1 and W_2, and pivoted at X. If the primary impulse is a differential pressure then a bellows is used to seal the shaft as shown. The beam controls a leak from nozzle *N* of air at pressure P_3 which flows to the nozzle through a restriction *R*. The reduced pressure P_4 is then applied to diaphragm D_2 where it balances the scale, and to the receiving instrument. This pressure bears a definite pressure relation to P_1, depending in the characteristics of the beam, counterweights and diaphragms.

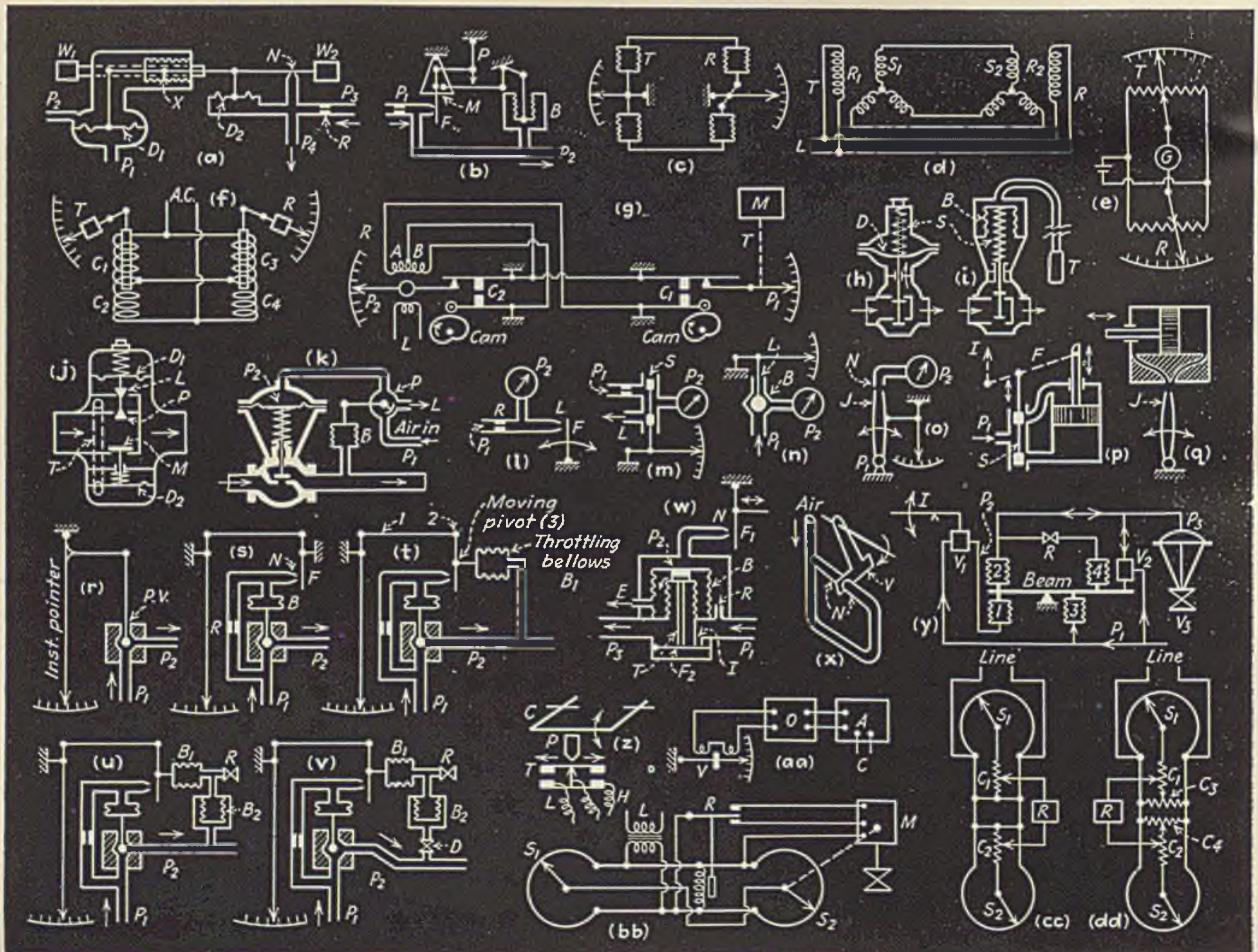
Another type of pneumatic transmitter (Brown) is shown in sketch (*b*). This device usually is employed in conjunction with a relay valve of the sort shown in Fig. 8 (*w*). Flapper *F* is controlled by the instrument pointer and serves to increase or decrease the flow of air from a nozzle. Air at pressure P_1 flows through a restriction and thence to the nozzle. The reduced pressure P_2 is then applied to the receiving instrument as a pressure proportional to the primary indication. The method of achieving proportionality is to apply pressure P_2 to a bellows *B* to which the moving pivot *M* of the flapper is attached. If the flapper moves toward the nozzle, raising the pressure of P_2, this in turn compresses the bellows, moves *M* to the right and tends to pull the flapper away from the nozzle, so that a definite flapper position is attained for each pointer position.

In Fig. 8 (*c*) is shown a hydraulic transmission (Liquidometer) used in transmitting level indications. The double bellows system is used for temperature compensation. Changes in the volume of liquid in the capillaries offset each other through the linkage shown.

Half a dozen or more different principles are used in electric telemetering devices. Fig. 8 (*d*) is a diagram of the circuit of a pair of self-synchronous motors which have three-phase stators S_1 and S_2 connected together and two-phase rotors R_1 and R_2 connected to the same line. If a primary impulse is applied to rotor R_1, the receiving rotor R_2 will turn by an equal amount. The rotors remain stationary unless turned by an external force.

The simple rheostat and ammeter, as used in automobile gasoline gages, has some industrial application, but more used are methods in which the rheostat is part of a wheatstone bridge circuit. Sketch (*e*) of Fig. 8 shows such a setup. Here the transmitting pointer positions a contact on a slidewire, and a

Fig. 8—Sketches (*a*) to (*g*), telemetering devices; sketches (*h*) to (*dd*), self- and servo-operated controllers



null-type galvanometer balances the bridge by causing the receiving pointer to move to the proper point on the receiving slidewire. A modification of this method is the induction balance, shown in sketch (f), which is a self-balancing a.c. bridge. A pair of coils in series at the transmitting end, C_1 and C_2, is connected with a similar pair, C_3 and C_4, at the receiving end. A balanced iron core at each end seeks the same vertical position so that if one is positioned by the transmitter pointer, the other positions the receiving pointer.

Another popular method is for the transmitter end to send electrical impulses of duration proportioned to the magnitude of the quantity to be telemetered. One variation of this idea is shown in Fig. 8 (g). This system (Bailey) uses two synchronized cams driven by clock motors and synchronized by a method not shown. These close contacts at each end, C_1 and C_2, for a period proportional to the position of the pointers, P_1 in the transmitter T, and P_2 in the receiver R. If the duration of contact at each end is not the same, the reversing motor in the receiver drives the receiver pointer to the proper point. When both shading coils A and B in the motor are either shorted or open, the motor can not run, but if one is shorted and the other open, due to unequal contact, the motor runs until both contact times are equal.

Telemetering methods are being used also for remote operation to centralize manual control. Various ways are possible, for example, by the use of self-synchronous motors. One can be geared to a valve handwheel, while the other is used to drive a distant valve. Pneumatic telemeters can be used to operate remote diaphragm valves. Or an electric-motor-operated valve can have its pushbutton at the point of use, while some form of position-indicating telemeter shows the valve position.

6. AUTOMATIC CONTROL

In classifying controllers according to the type of response, three main variations are noted. In the first are fixed-position controllers which respond to the need for a correction by producing a certain fixed rate of flow. In this group are two-position (on-and-off) controllers which give a maximum or minimum flow rate and multi-position controllers which can select the best of several possible flow rates, depending on the deviation. The second class of controller gives a response which is determined by the direction of deviation, but imparts a final valve position which bears no relation to the value of the variable, and so is known as floating. The third class of controller is capable of selecting the desired flow rate from a continuous range of possible flow rates.

The simplest form of class (3) is known as proportional-position, proportional, corresponding, or simply as throttling. With this type the control point droops with changes in demand (see page 104) so that the next step in controller design is to add an automatic means for resetting the control point to maintain a constant control point regardless of changes in demand. Such controllers are known as proportional-plus-reset, or simply as reset controllers. A third variation of the proportional controller adds another function which aids it in reaching a new stabilized final control valve position quickly after a change in demand (see page 106). This function moves the valve at a rate proportional to the acceleration of the change in deviation, and so is referred to as a second derivative function.

Controllers may also be classified by the source of energy which they use in effecting corrections. They are either self-operating or pilot-operated, although an intermediate class using the pressure of the material being controlled to amplify controller responses is also used to some extent.

In Fig. 8 (h) to (dd) are shown a variety of controller types and controller elements which seek to show the most used fundamental types, but the selection is by no means exhaustive. Sketch (h) represents a simple self-operating pressure regulator or reducing valve in which the valve opening depends on the interaction of the downstream pressure on diaphragm D, and the force of the opposing loading spring S. Adjustment of S adjusts the control point. A very similar principle is met in self-acting temperature regulators such as (i). The thermometer system, consisting of bulb T and bellows B, is filled with a volatile liquid or a gas. Working against the adjusting spring, it positions the valve to control the flow of fuel or steam and so maintain the temperature.

The principle of the intermediate type controller of the pilot-controlled, self-operating type, is illustrated by Fig. 8 (j) which diagrams a pilot-operated reducing valve. Pilot valve P allows some of the high pressure material to leak through L to the low pressure side, applying the intermediate pressure between the two pilot needles through tube T to the under side of diaphragm D_2 which controls the main valve M. The pilot position in turn is controlled by the interaction of the downsteam pressure acting on diaphragm D_1, and the force of the diaphragm-opposing spring.

For most control problems where more power is needed than is available in self-operating devices, the primary instrument response must be amplified pneumatically, hydraulically or electrically for indirect application to the final control element. Fig. 8 (k) is a diagram of a simple pilot-controlled pressure controller, using air under pressure (usually about 15 lb.) as the amplifying means. The pilot valve P is positioned by the bellows B so as to throttle the air pressure applied to the final control valve diaphragm and so give the desired opening of the control valve. For clarity a rotary type three-way pilot valve is shown. It is obvious how pressure P_2 can be controlled by choosing the proper relation between the opening of the air inlet and the leak L. A leak or its equivalent is necessary in all fluid-operated throttling controllers.

Sketches (l) to (o) of Fig. 8 show four fundamental types of pilot valve. Several variations are used, for example that shown at (x). In (l) is the commonly used flapper type in which air inlet pressure P_1 is throttled first through a restriction R and then through a nozzle leak L, under control of flapper F which is positioned by the instrument pointer. The resultant pressure P_2 is proportional to the nozzle opening, and hence related to the position of the pointer. Sketch (m) shows a slide valve S, the position of which determines the relation of inlet and leak, and hence controls P_2. A restriction is necessary. The common ball valve type is diagrammed in (n). The position of the ball determines the amount of leak at L, and also introduces the necessary restriction, thus determining P_2. This is similar to the slide valve type. In sketch (o) is the noval jet-pipe type used by Askania. Depending on the position of the jet, more or less of the velocity pressure of a liquid issuing from the pipe under pump pressure is converted to static pressure in the receiving nozzle. The jet is positioned by the measuring instrument.

The pressure P_2 produced by any of these pilot devices may be applied to diaphragms, pistons or bellows to position the final control device. Most common is the so-called diaphragm motor diagrammed in sketch (k) of Fig. 8, which is used to operate valves and dampers. Since such a diaphragm is opposed by a spring a definite opening (within limits of friction) will be produced by a definite pressure P_2. Pistons and bellows may also be opposed by a spring. An alternative method is shown in Fig. 8 (p) which shows a slide valve S controlling a piston. Without the lever F which is shown dotted, there would be no relation between piston position and the measured quantity which positioned the slide valve, for the piston would move to one extreme or the other unless arrested by neutralization or opposite movement of the slide valve. Addition of F, which is called a follow-up, causes the piston movement to reposition the slide valve to stop the movement. Thus a definite instrument change will produce a definite piston movement. Such an arrangement, either with or without the follow-up, is often used for positioning large valves. In program control of valve opening and shutting the follow-up is not required. It is needed only where throttling valve action is used. The jet-pipe method of positioning a piston is shown in sketch (q). Instead of a single receiving nozzle as in (o), two are used.

The development of a pneumatic pilot system to encompass the various types of control mentioned in the opening portion of this section is shown in Fig. 8 (r) shows the same arrangement as in sketch (n), namely, a ball pilot valve P.V. which receives air at pressure P_1 and throttles it to P_2 for use in controlling the opening of a final control valve. In this form the pilot valve is capable of throttling, but it has a slight reaction on the measuring system and so is not of highest accuracy. The reaction on the measuring system can be much reduced and the amplification increased by interposing the relay system shown in the next sketch (s). The instrument pointer here positions a flapper F before a nozzle N, causing bellows B to control the position of the ball valve. A restriction R must be used in the nozzle supply line. Air supply pressure is reduced from P_1 to P_2 by the ball valve. In this type, such a small movement of the flapper is needed to change P_2 from maximum to minimum that such an arrangement is difficult to use for throttling types of control. Instead, it is used for two-position (open-and-shut) control.

The third sketch, Fig. 8 (t) shows how (s) can be modified for throttling control by the addition of a follow-up, similar in principle to its mechanical counterpart in Fig. 8 (p). This is accomplished by adding a throttling bellows B which is positioned by the controlled pressure P_2. As this bellows carries a moving pivot for the flapper, it opposes the initial change in flapper position and after a pressure change produces a definite new flapper position which is proportional to the new instrument pointer position. Thus proportionality between the measured quantity and pressure P_2 is obtained, but the flapper will assume a slightly different position for every value of the instrument position, so that every value of the controlled load will give a different control point. That is, the instrument will have droop. How much droop will depend on the amount of pointer movement needed to full-stroke the final control valve, a characteristic which is adjustable in most throttling types of controller.

Many controllers get away from the difficulty of droop by the use of automatic reset, the next step shown in Fig. 8 (u). In sketch (o) rapid movement of the piston (without the follow-up) would give open-and-shut control, while very slow movement, which would allow the controlled condition to be affected quickly enough to arrest the piston before it reached the end of the stroke, would give floating control, which as previously noted has no relation between the measured value of the variable and the position of the final control element. To compensate a proportional controller for its drooping characteristic, it is only necessary to add a floating component, as in sketch (u). The addition consists of a second bellows B_2 and a reset valve R to control the rate of reset. The initial effect of a movement of the flapper is exactly the same as with sketch (t), that is, B_1 moves the moving pivot of the flapper so as to oppose the initial pressure change. At that point, however, the slow equalization of the pressure in the two bellows with that of the atmosphere begins to take effect and a second movement of B_1 takes place, opposite to the first, thus resetting the flapper to a slightly greater opening or closing than the initial movement.

Addition of second derivative action is shown in sketch (v) of Fig. 8. This consists of a restriction, or second derivative valve D, which is inserted between B_2 and the controlled pressure system for the purpose of slowing down the follow-up action of B_1. Thus an initial change in the flapper produces an immediate large change in the controlled pressure but this is brought back gradually to the desired final pressure as the controlled pressure leaks through D. The two valves, R for setting the reset rate, and D for setting the time required for taking off the second derivative action, are used to tune the controller to the characteristics of the particular process with which it is to be used. Sometimes, especially for use in batch processes, second derivative action is used without reset on a proportional controller, which means elimination of valve R.

Sketches (r) to (v) of Fig. 8 show the principles used in most actual pneumatic controllers, although many different equivalent devices are adopted for obtaining the desired results. Features present in actual controllers, but not shown in the sketches, are the methods for altering the control point and changing the throttling range. The former would be adjusted by some means of changing the length of link (1) in sketch (v), and the latter, by moving pivot (2) closer to or farther from pivot (3).

Some of the special variations of the pneumatic methods discussed are shown in Fig. 8 (w) to (y). At (w) is a non-bleeding type of relay air valve (Brown) which is claimed to have high sensitivity but to require a minimum of air, the only leak being that at the flapper. Air at pressure P_1 passes through a restriction and into the space outside a double bellows B, flowing to the nozzle N where the pressure in the nozzle system is controlled by a flapper F_1. If the bellows is in the balanced position, the exhaust tube T is closed by flapper F_2 which also closes the inlet port I. Pressure is then at P_3 in the output system. Assume a change in position of flapper F_1 which raises the nozzle pressure P_2. This forces tube T and flapper F_2 downward, opening I and raising P_3 until the force against the small bellows balances that against the larger bellows, when I is closed at the new value of P_3. On the other hand, a reduction in nozzle pressure lifts tube T, exposing the exhaust port and reducing P_3 to its new pressure corresponding to the position of flapper F_1. A follow-up, not shown but equivalent to that of sketch (b), is used to give a definite position to flapper F_1.

The free-vane type of flapper (Bristol) shown in sketch (x) has been developed to reduce the reaction on the instrument pointer encountered with the type of flapper shown in earlier sketches. As is self-evident from the drawing, a vane moves between two opposing air nozzles without contact, to control the nozzle pressure.

In certain air-operated controllers having an electrical measuring system (Leeds & Northrup) the pneumatic balance system shown in sketch (y) of Fig. 8 is used. The instrument I has a cam which positions primary air valve V_1, to control the pressure on bellows (1) which bears against a balance beam. Bellows (3) achieves an initial balance of the beam which positions secondary air valve V_2. The output pressure P_2 is applied to the final control valve V_3 and also to bellows (2) which acts initially as a follow-up, but as the pressure between (2) and (3) is equalized through reset valve R, this follow-up action is taken off, so that the final position of V_3 is reset to the requirements for the new demand.

ELECTRICAL CONTROLLERS

In the foregoing control instruments have been discussed as if control were always pneumatic or hydraulic. Actually, electricity is often used as the medium for translating control impulses into final responses. Its action is akin to other amplifying methods in that only a light contact in the primary instrument is needed to control a circuit, although if the controlled circuit carries more than a minimum of current, some form of relay positioned either mechanically or by the primary current is needed. One method of closing controller contacts mechanically to overcome the low power available from the measuring instrument is shown in sketch (z) of Fig. 8. Here the instrument pointer P moves over a tilting contact table T, and is periodically depressed by a chopper bar C. The control point is at the table pivot so that deviation of the controlled variable, evidenced by the position of the pointer either side of the center, will tip the table one way or the other and close either the high contact H or the low contact L. Many other mechanically operated devices are used, generally to close mercury switches or snap-acting open switches.

Another method for offsetting the weak primary action of the measuring instrument (Wheelco), which is one of several ways to use electronics for this purpose, is shown in sketch (aa) of Fig. 8. Here the instrument pointer carries a light metal vane V which moves into or out of the field of a pair of small coils which are part of the tank circuit of an oscillator O. Presence of the vane between the coils changes the oscillator tuning to operate the amplifier relay A and close the control circuit C.

Where two-position control is used, contacting primary instruments can open and close valves or other final control units. If throttling valve action is needed, some method of obtaining valve action proportional to the measured variable is needed. The most usual method is to employ a primary instrument in which the indication of the variable can be expressed as position of a slider on a rheostat or slidewire. Then it is only necessary to use a wheatstone bridge circuit with a second slidewire or rheostat positioned by the valve motor to attain a proportional position for the valve. The remaining sketches show different developments of this idea, comparable to the development of the pneumatic controller shown in Fig. 8 (t) and (u). Sketch (bb) shows a simple proportional hook-up which has a droop characteristic similar to (t). The instrument positions slidewire S_1, and through action of the relay R and valve motor M the final control valve is moved and with it slidewire S_2 until the bridge is again in balance. To add throttling range adjustment some arrangement equivalent to that shown in (cc) is used (Brown), with two more resistances and contacts C_1 and C_2. These can be varied to change the resistance of the motor slidewire, and so permit the bridge to balance with any desired proportionality between the movements of S_1 and S_2. Another refinement is shown in sketch (dd), for the purpose of adding reset to the circuit. Since resetting a controller is equivalent to moving the throttling range up- or down-scale, this can be accomplished by the addition of another pair of resistances and contacts, C_3 and C_4. When the contacts are moved simultaneously they change the resistance at one end of the motor slidewire, and at the other end of the instrument slidewire, thus achieving a relative shift in balancing points for the two slidewires. This shift can be handled manually, but is also performed automatically by a resetting motor in the instruments of several manufacturers.

Automatic Control Terminology

EDITORIAL STAFF

Editor's Note: Despite the fact that much effort has been expended in attempts to develop a uniform terminology in the field of industrial instruments and automatic control, this effort is far from complete and there are still many disagreements among various writers in the field on the best word to use for a given purpose. As a consequence, the literature is sometimes hard to follow. The list given below makes no pretense to being either complete or a final authority on definitions, but it may help readers, particularly where several expressions are commonly used to describe the same idea. The editors have borrowed freely from many sources.

Accuracy: A numerical value which defines the limits of error of a measurement, usually in percent of an instrument scale.

Automatic control (or regulation): The act of maintaining the indicated value of a variable within prescribed limits, or of varying the value of the variable according to a desired time-quantity relation.

Capacity lag: A process lag (q.v.) which results in a retardation of the detection of a change in value of a variable due to energy or material capacity.

Control band: See throttling range.

Control element: See final control element.

Control point: Desired value of a controlled variable.

Controller (instrument) lag: Delay in effecting correction of a change in a controlled variable due to a delay or retardation in any part of a control instrument.

Damping: Effect due to whatever cause, tending to hinder or prevent oscillation.

Dead time: See process lag.

Dead zone: Range of measured values of a variable in which an instrument cannot detect or initiate corrections of a change.

Deviation: Departure of the value of a variable from the desired or normal value.

Distance-velocity lag: Delay in detection of a change in a measured value of a variable due to the need to transport material to the point of measurement.

Drift: See droop.

Droop: Shift in equilibrium or average value of a variable owing to an inherent characteristic of an automatic controller.

Droop correction: (Also drift.) See proportional-plus-reset.

Final control element: Valve, rheostat or other element which receives corrective impulses from a controller, and in turn makes corrections tending to return a variable to the control point.

Floating control: Type of control action which varies a flow without a definite relation, other than direction of change, with the value of the variable.

Follow-up: Device which is used with relay elements in controllers to establish a definite control response for a given change in variable by setting up a counter response.

Hunting: Controller cycling or oscillation.

Indication: Measurement of the instantaneous value of a variable.

Industrial instrument: Device for measuring or measuring and controlling the values of a process variable.

Load error: See droop.

Measurement: Indication of the instantaneous value of a process variable.

Measuring element: Part of an instrument which indicates instantaneous values of a variable.

Multiposition control: Type of control response which selects one of several definite rates of corrective action depending on the deviation of a process variable.

Non-corresponding: See floating.

Offset: See droop.

On-and-off control: See two-position control.

Pilot valve: Device for controlling the flow of an auxiliary fluid used to amplify the power of a controller measuring system in effecting control.

Positioning control: See proportional.

Precision: Closeness of agreement of repeated measurements of the same quantity.

Primary sensitive element: Device which senses changes in a process variable and determines magnitude of change, without indication.

Process lag: Includes capacity lags, transfer lag, distance-velocity lag and reaction lag; any retardation or delay in bringing information concerning a change in variable to the primary sensitive element of an instrument.

Process variable: See variable; related specifically to processes.

Proportional band: See throttling range.

Proportional control: Type of control response which adjusts the final control element to a definite relation with the measured value of the variable.

Proportional-position control: See proportional control.

Proportional-plus-reset control: Type of proportional control which eliminates droop.

Proportioning control: See proportional.

Proportional response: See proportional.

Pyrometer: Device for measuring high temperatures.

Reaction lag: Process lag due to the time necessary to complete a reaction before the result of the reaction can be measured.

Relay: Usually means electrical relay, but is also used to designate other amplifying means such as a relay air valve.

Reset: See proportional-plus-reset. If automatic reset, a type of control response giving a rate of valve movement proportional to deviation of the variable.

Scale error: Difference between true and indicated values of a variable.

Second derivative control: Type of control response giving a rate of final control element movement proportional to the acceleration of the change in deviation.

Self-acting (or -operating) controller: Type of controller employing the power of the measuring system, without amplification by an auxiliary power source, to effect necessary corrective action.

Sensitive element: See primary sensitive element.

Sensitivity: Ratio of effect to cause in an instrument, such as ratio of valve movement to pen movement.

Servo, servo motor: Auxiliary power-operated amplifying device used in instruments to position final control element under control of the measuring element.

Three-position control: See multiposition control.

Throttling control: Type of control which is able to position its final control element at any position between maximum and minimum limits. Sometimes means proportional only.

Throttling range (zone): Range of measured values needed to cause maximum possible change in final control element setting; usually expressed in percent of full instrument scale.

Transfer lag: Retardation in effect of change in variable on primary sensitive element due to capacity effects or resistances on supply side.

Two-position control: Type of control response in which final control element can be positioned only at a maximum or minimum position.

Variable: Physical quantity which is variable with time.

A View Into the Next Decade in Industrial Instruments

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The tremendous impetus which the war has given to the advancement of instrumentation will affect the process industries in a way which can be known only after the official cloak of secrecy has been removed. Some trends already apparent are given in this article.

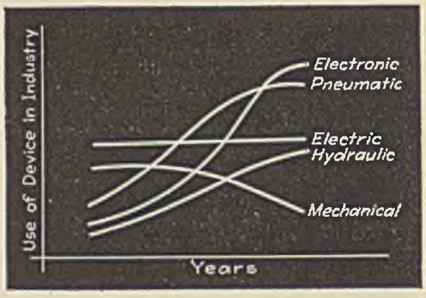
—Editors.

WILL ELECTRONIC methods replace other existing means for measurement and control, to a predominant extent? Probably not. The magic word "electronics" has served advertisers so well in attracting the public interest that its reactions have catalyzed further effulgences. This chain reaction has impressed technical people, also; the electronic engineer being impressed by what is expected from him; the non-electronic engineer by what might be done for him.

Remarkable as electronic developments genuinely are, there will always be numerous jobs which can be done as well, or better, or cheaper by alternative methods, some of which have also earned glory of their own.

Measurement of a physical phenomenon starts with some simple related effect. (Phenomenon — temperature; Effect — expansion, thermo-electric potential, radiation, etc.) The related effect is transmitted to a pointer on a scale which is suitably calibrated in terms of the phenomenon to be measured. A control element can be associated with the indicator, either directly or remotely. Thus, we have detection, transmission, indication and control, occurring in numerous different combinations.

The energy required for actuation of controls can be drawn from the seat of the measured phenomenon (self-actuation) or it can be taken from a different source (servo-actuation).



Instrument trends

There are five transmitting and control-actuating principles:

1—Electronic
2—Electric,—other than electronic
3—Hydraulic
4—Mechanical
5—Pneumatic

"An electronic apparatus is a device in which electric conduction current is carried through a vacuum or gaseous space."[1] This definition distinguishes Item 1 from Item 2.

Electronic and pneumatic devices will advance most rapidly, with hydraulic also gaining (primarily in the machine tool field), electric holding its own and mechanical losing out. The above diagram illustrates these trends.

Electronic devices enter into industrial instrumentation in three distinct ways: (1) as an extra quick relay capable of carrying as much power as may be necessary, (2) as an amplifier for multiplying the strength of weak primary impulses to the point where an indicator can cover a broad scale, and (3) as an actual detector and measuring instrument.

The most important advancement of electronic devices will probably be in installations where speed is essential. For relays where speed is not required pneumatic or hydraulic methods often function equally as well as electronic and are more simple. At present, electronic amplification of primary impulses is used in a number of industrial instruments where extremely quick recording and/or control is needed. This applies particularly to null devices such as potentiometers and balanced wheatstone bridges which now employ (1) electronic balancing without a galvanometer, (2) photoelectric balancing with a galvanometer or (3) ultra-rapid galvanometer contact control through electronic amplification.

Further development of simple and inexpensive servo-operated transmissions and controls, combined with more exacting requirements, will probably make it difficult to sell self-actuated control devices except for the simplest applications. Self-actuated transmissions will also be replaced by servo-transmissions for many remote measurements. Pneumatic transmissions can be expected to capture much of this latter field, electric transmissions will always be used, and there may later be new competition from simple radio (wireless) transmission of measurements. A present-day example is the radiosonde, which transmits to earth its measurements of high-altitude atmospheric conditions.

The electron microscope will be simplified and reduced in cost to such a degree that it will be commonly used in laboratories large and small. Already, both General Electric and R.C.A. are offering relatively small, low-cost instruments. The normal course of development and application can be expected to materialize here, in a manner typical of all fundamentally important equipment. Thus, will the art of measuring the ultra-small be advanced.

Although lighting equipment cannot be classified as instrumentation, it seems fitting to mention that tremendous application of electronics, fluorescent lighting. It also represents a fundamental advance in quality and cost reduction in its field. It can be expected to continue its phenomenal spread.

A notable development in the field of electric control was signaled by the introduction of that "mechanical vacuum tube," the General Electric Amplidyne generator. Its Westinghouse companion is the Rototrol.

The Amplidyne generator is a rotating machine in which the normal field/armature amplification of an ordinary direct current generator is compounded so as to provide an overall amplification in the order of 10,000 to 1. Thus, weak input signals can create very large corresponding changes in the output power. It has found wide application already, and the coming years will almost certainly bring an extensive recognition of its capabilities, with consequent expansion of its use.

The true throttling action which has been made readily available in electric control systems by electronic means, enables electrical control to handle various problems which have been more economically taken care of pneumatically. Conversely, the use of pneumatic controllers with their inexpensive provisions for widely adjustable throttling range, automatic reset, etc., will probably be used more extensively for controlling-rheostats, adjustable ratio transformers, etc., to control various electrical systems. An example is the control of a vibrating feeder by adjustment of its input voltage with an air motor under the influence of a pneumatic temperature controller.

Recording and automatic controlling equipment will extend more deeply into a field which can use it to good advantage, but which as yet does so to relatively little extent. That is the field of research and development, in numerous industries. Although the saving of laboratorians' time is of some importance, the chief advantage in spending money for automatic recording and controlling laboratory apparatus is that, by their use, more reliable data can be obtained and more certain interpretations can be formed. In fact, continuous recording of experimental data often times discloses information which the researcher would otherwise have missed completely. Development projects can be completed in shorter time, and their results more quickly put into profit-paying service.

DISTILLATION AND FRACTIONATION

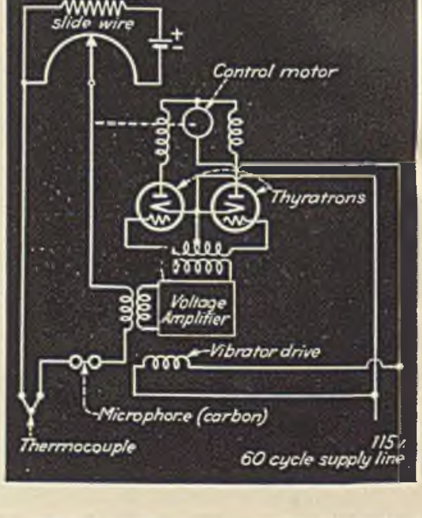
Reduction of measurement lags combined with better understanding and use of derivative effects (effects of rates of change) will characterize advances in measurement and control in distillation processes. Control engineers and process engineers will participate mutually.

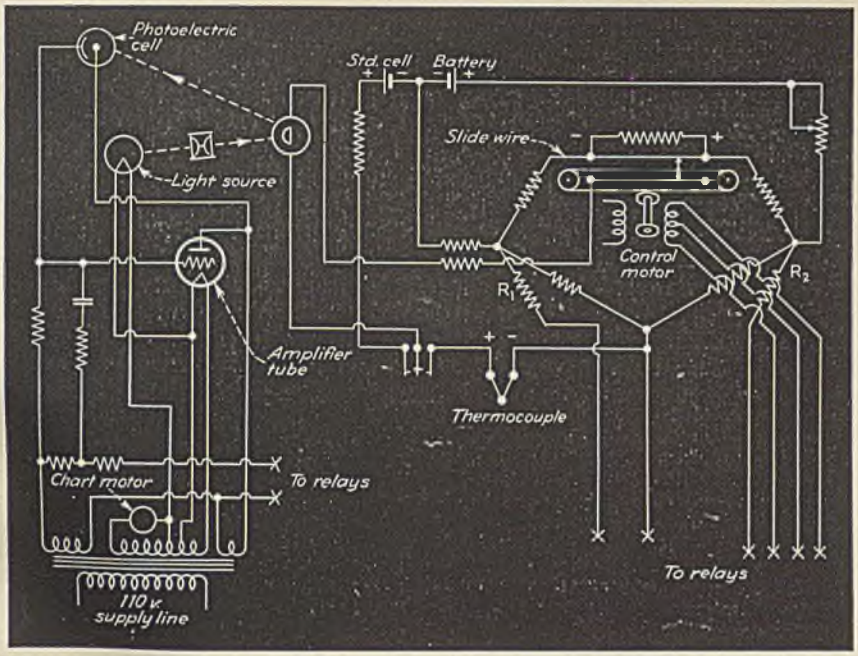
Diaphragm and bellows-actuated flow responsive instruments will increase in popularity. Their measurement lag is uncommonly small because acceleration and friction forces required to move mercury are absent. This difference is of pronounced importance in precise control of continuous fractionation, as well as in other processes where small parasitic hunting cannot be tolerated.

Measurements of unsteady temperatures will be made more accurate by development of more nearly "lagless"

Electronic relay circuit

This Leeds and Northrup circuit uses a microphone to chop thermocouple d.c. which then controls thyratrons to energize motor and adjust slide-wire. A magneto coupled to motor and opposed to thermocouple e.m.f. prevents overshooting and hunting





Photoelectrically balanced slide-wire potentiometer

A single phototube is used in this circuit by C. J. Tagliabue Mfg. Co. to vary the current in the amplifier tube and thus throw in the relays when the galvanometer is deflected. In opening or closing the relays, one of them is delayed to trap the galvanometer and hold it in the balanced position

thermometer bulbs and by wider use of good installation practice.

More general grasp of dynamic aspects of measurement and control, both in process and in controller, will contribute to better combinations.

DRYING

Moisture measurement and control in various materials is still one of the most troublesome problems in industrial drying. Electronic devices for detection will have this field practically to themselves. The chief cause of inadequacy in existing equipment for the purpose (itself electronic) probably lies in the "related effects" of moisture content upon which the measurements depend. There appears to be no single predominant effect which is simply enough related to moisture content to serve satisfactorily as a continuous measurement basis. Future development might introduce corrective mechanism to compensate the influence of extraneous variables which now cause trouble.

Radio frequency heating[2, 3] will expand rapidly as soon as the necessary equipment once more becomes readily available. Heat can be rapidly generated within great depths of a nonconducting material, by virtue of the dielectric energy "loss" which occurs when the material is exposed to a strong electrostatic field of radio frequency. The uniformity of heating permits close adjustment of moisture content in entire casks of tobacco, bales of cotton and the like. Probe type moisture detecting elements used in combination with radio-frequency heating can be expected to accomplish new economies in future production.

FLUID FLOW

Diaphragm and bellows-type flow instruments will be used more widely, particularly for control as discussed in reference to distillation and fractionation. The current trend toward wider use of variable-orifice constant-differential meters (rotameters) will continue for some time, but by no means to the exclusion of fixed-orifice variable-differential devices.

GRINDING

Better and less expensive apparatus for the control of feed rate and fineness of product will find an attractive market. Pulverizer manufacturers will probably commence furnishing automatic controls with their machines. Automatic feed control has been marketed for several years (Max Mosher—load control; Hardinge Co.—sound control) but there is no automatic control of fineness known to the author.

HYDROGEN ION CONCENTRATION (pH)

Measurement of pH will use the glass electrode more and more predominantly. Electronic amplification of the electrode potential will probably remain the only way it can be done. Further development in glass for electrode use and development in electrode design will combine to increase the useful range, the reliability and the operating ease of glass electrode equipment.

Rapid expansion of automatic pH control waits largely upon realization by user engineers of the critical importance of all parts in the process. Apparatus which is expected to feed reagent satisfactorily is often erratic in its performance and poorly responsive to the efforts of controllers. Provisions for mixing and reaction times are frequently inadequate because process engineers have not realized their true influences in the problem of control. Sampling arrangements are not as they might be, and there are frequently unfavorable measurement lags. The net result is that the automatic control of pH has experienced more than its share of troubles.

In view of the fact that many unfavorable conditions can never be eliminated from processes requiring pH control, the control engineer will take advantage of various derivative effects, namely the effects of rates of change upon and in control.

MATERIALS HANDLING, WEIGHING

Automatic control of material flow to and from process steps could profitably be used more than it is now. The control adaptability of vibrating conveyors and feeders will result in a further trend toward them and away from rotating mechanisms, which must be controlled by motor speed, percent-time-on, etc. Combinations of existing controllers with existing feeders will become more common.

Apparatus for automatic continuous weighing is now predominantly electric and is unnecessarily complicated and expensive. Adaptation of pneumatic control can be expected to relieve the situation. Similarly, automatic batch weighing suffers from excessive complication and cost. New ideas will bring profit-making improvements.

Remote transmission and control of weighing has lagged regrettably. It is also handicapped in its market expansion by the closed ring: high cost inhibits market growth, small market inhibits cost reduction. There is no good technical reason for this state, and the next few years should bring relief through the use of simpler mechanisms, probably pneumatic.

STATISTICAL ANALYSIS

The past few years have seen a rapid increase in the use of industrial statistics for quality control. Several authors have followed the lead of Dr. W. A. Shewhart[4] of the Bell Telephone Co. in publishing books on this subject. Industry has profited, and will profit further by more wide-spread understanding of the advantages which can be gained by formal statistical analysis of quality in manufactured products.

The industrial statistician has been handicapped by lack of mechanical aid in the collection and manipulation of data. Someone will probably put on the market a continuous analyzer along the lines suggested by Herbert Ziebolz[5], who has proposed a special tabulating machine arranged to plot the distribution curve representing a group of data. Extension of his work might well lead to special computing instruments which would turn out the standard deviation and other more complicated statistical indices much more quickly than they can be computed at present.

TENSION CONTROL

A field for modern measuring and controlling apparatus which has been neglected too long is that of tension control in traveling strand and strip materials, such as paper, textiles, synthetic films, etc. The textile industry in particular needs better measurement and control of tensions. The need could be satisfied by existing industrial instruments, at the additional cost represented by more than usual application engineering, particularly during introductory years.

Manufacturers of synthetic fibers and films have, to a large extent, been forced to provide themselves with modern tension control apparatus. However, the field is relatively new, even in those processes, and industrial instrument application can be expected to expand rapidly there.

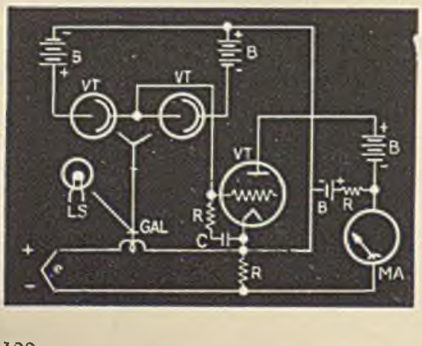
Another application of modern instrumentation in this same field is the creation, measurement and control of roll pressures in calenders and similar machines. Here, again, the adaptation of existing industrial instruments to a relatively new service is delayed only by the application engineering which is required. Attractive advantages have been demonstrated, and as soon as a wide-spread realization of these advantages becomes known among users, another avenue for the growth of industrial instrumentation will become important.

Precise indication and control of clearance between calender roll surfaces is also of critical importance in machines for coating and impregnating textile and fibrous sheets. Electronic gaging has been applied here to expand a few mils roll clearance over the 4½-in. scale on a recorder chart. Further applications of this sort can be predicted.

Electronic gaging has been successful in precise measurement of sensitive springs. Pneumatic gaging rapidly measures and records the inside dimensions of long gun bores. Other advances in gaging instruments will become widely known after the war.

Weston self-balancing potentiometer

Part of the amplifier plate current is fed back into the galvanometer circuit deflecting the mirror and illuminating one of the phototubes. The phototube circuit, thus unbalanced, changes the grid bias which in turn regulates the plate current. To prevent oscillating or hunting, a shunted capacitor is inserted in the grid circuit of the amplifier



VALVES

The valve situation has been unsatisfactory to control engineers because controller manufacturers have frequently looked upon valves only as a necessary nuisance, while most valve manufacturers haven't known much about control. Control engineers, themselves, have been too little familiar with the critical influence of controlled valve characteristics upon the performance of the controlled processes. They have not been sufficiently familiar with methods[6] for predicting the best valve characteristic for a specific application. Future years will probably find control engineers making more specific demands upon the people who furnish their valves; and, correspondingly, controller manufacturers will be prepared to recommend and furnish a wider selection of valve characteristics, more definitely known than now, without the cost burden which is now attached to any valve which can't be ordered from a brief table in a catalog.

The importance of valve positioners is rapidly becoming more widely recognized. This fact, combined with the trend toward processes which require more critical control, will no doubt, bring about a considerable increase in the percentage of valves which are equipped with positioners. It is also expected that there will be further simplifications in positioner design, with corresponding cost reduction. Insofar as valve materials are concerned, the only definite trend which seems predictable is toward the more extensive use of porcelain for the handling of corrosives.

QUANTITATIVE ANALYSIS

Electrical design experienced one of its most significant advances when Steinmetz showed that complicated phenomena in electric machines can be reduced to quantitative mathematical terms. When it became possible to compute the exact performance of machines already built and tested, it became equally possible to predict the characteristics of machines not yet built. Furthermore, the parts of a mathematical structure could be manipulated in devious ways and solved for an unknown, in exact numerical dimensions. But the best dimensions for one of many parts could not be shaken out of a basket of physical pieces!

A mathematical structure can be built and mathematically tested; torn apart and redesigned and rebuilt; thrown away and a new one put in its place; all at a fraction of the time and money cost which would have been required to arrive at the same result by building and testing machines. Thus did quantitative analysis help put the electrical industry on a sound and profitable basis.

The science of control is in its infancy of practical mathematical development. Mechanisms are not what they should be, and applications are haphazard because procedures for analytical construction and testing of controls have not yet been developed to the state of common practical use. But encouraging beginnings have been made; and the next ten years can be expected to bring us to wide and profitable use of new analytical tools, designed for our own specific needs.

The standardized nuts and bolts and screws of our new analytical tooling will be represented by a standard terminology for control. The lack of a common language to hold the parts together is a serious handicap to fundamental progress. The establishment of terminology and of analytical procedures which "work" will enable process equipment designers to recognize control engineers' problems and to understand their solutions. The natural result will be improvement in design for control, and more profits for industry.

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Considering Controllability in Plant Design

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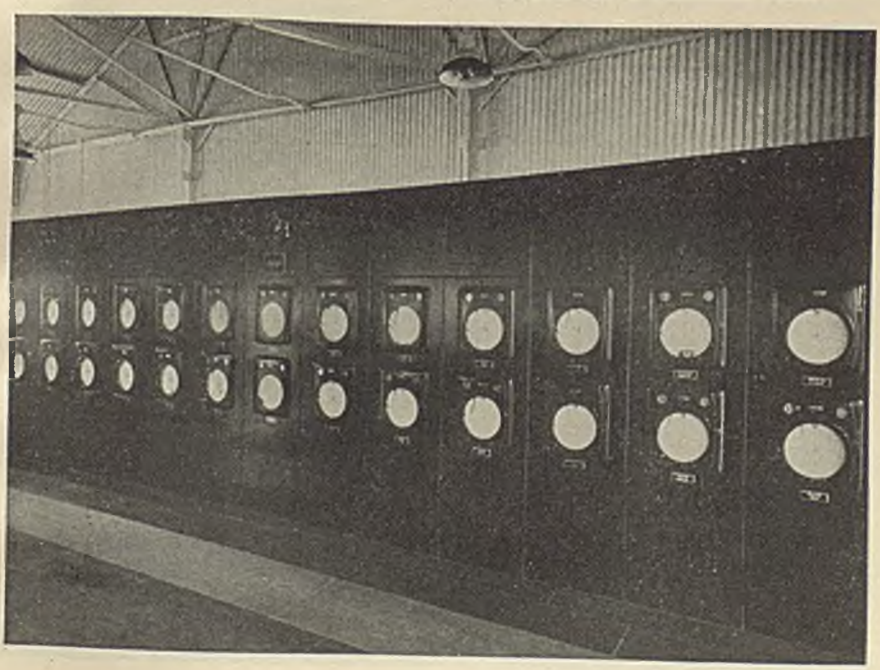
In discussing controllability in plant design Mr. Haigler treats controllability in process development, in plant layout, and in equipment selection. Further, he has much to say regarding proper evaluation of controls in process industry plants. —*Editors.*

It was but very few years ago that accepted procedure in plant design was to consider instruments and operating procedures as one of the very last steps, perhaps even after construction was well along. A few meters for transactions with utilities were accepted as a matter of course. Even a few meters for accounting for steam and water uses within the plant might be suggested. But when it came to recording and control instruments for the process, the problem was to select a few instruments which might be useful, which would not be a burden for some one to maintain in addition to other work, and which would not provoke any caustic comments about extravagance. Centralized panel assemblies like Fig. 1, or like the installations in the synthetic rubber units built and building did not result from this approach.

Then plant by plant, as the result of scattered experiences of unusual savings, of occasional comparisons of duplicate units with and without automatic control, of intriguing knowledge of new capabilties of instruments, the financial limitations were relaxed and all manner of ingenious gadgets were *attached* to the process. Where conditions were favorable, whether fortuitously or by empirical or intuitive selection of applications, the results were all that could be expected and the returns on the capital most satisfactory. But unsuccessful applications were common, and too often unexplained.

Soon, however, analytical approaches were attempted, and with ever increasing certainty it became possible to predict what would or would not work. Progressive plant designers and process engineers began to consider control when selecting and laying out equipment with correspondingly improved results. Then farsighted development engineers began to consider control, not only for improvement and economy in pilot-plant work, but because the economic success and in some cases the very feasibility of a process seemed to depend on the solution of control problems.

Fig. 1—Main control board at La Gloria Corp. plant at Falfurrias, Texas



Since chemical processing seems to have developed most rapidly and profitably where progressive views on control technique prevail, and since process characteristics have such overwhelming effect in matters of controllability with instruments, as well as without, it is desirable to survey the important aspects of process design for controllability. They apply, of course, to plants and plant elements to be operated automatically, but they apply also to those which are not automatic, for the penalties of neglect there may be even greater.

First, has controllability been considered in process development? Can the process be operated safely and stably? Perhaps, you say, this is a tried and tested process and no significant change is contemplated in this new unit. Well, perhaps so, but it is never amiss for a control engineer and a process engineer to take another good look at the process. Some seemingly minor changes as simple as reversal of connections on a heater do have considerable control significance. Newly available industrial instruments may make a change desirable. Changing manufacturing conditions as to cost and availabilty of equipment, of raw material, of operating and maintenance labor, and of supervision can change the control picture completely. Changing selling conditions likewise may revise the outlook, especially when competing firms or industries adopt automatic process control as a way of changing "going" quality and price. Also one must not forget that automatic control, being continuously attentive but unreasoning, is not best applied in the same way as manual control. On-off control, which finds such wide use, is utterly different from manual control. Perhaps on the other hand, it is a new process new in principle, newly converted from batch to continuous operation, or newly expanded in scale and changed in equipment. Then, especially, take a good look at controllability. Unadvertised, of course, but far from unknown, are processes which are failures, and all too often the failure has been predicted by control-conscious engineers. Rebuilding costs time and money. So take a good look at controllability in the beginning—when it pays best.

Second, has controllability been considered in plant layout? Can the plant be operated conveniently? Perhaps the process elements are relatively independent, relatively simple requiring little attention, and controllability is not much of a factor in layout. Perhaps, on the other hand, it is a complex process where centralized control is necessary to efficient operation, or even to operation at all. When the amount of planning involved in securing a good layout of the operating position of a single process machine is considered, it is not hard to realize that a requirement for centralized control on a whole process can have important implications in plant layout. Recently built plants often have involved several hundred industrial instruments, half of which had to be on central control boards. A knowledge of what is practical in remote measurement and remote control must be considered early in the layout of such complex units. Otherwise higher initial cost, delays in construction, startup troubles, revisions, or operating difficulties may be expected.

Third, has controllability been considered in equipment selection? Can the plant be operated with minimum trouble? Perhaps the process and/or equipment is practically self regulating. Perhaps, on the other hand, inherent instability is inevitable. Perhaps, too, units are to be operated near maximum throughputs, with minimum margin of safety or margin of control —say on heating surface, or reflux rate, or favorable energy storage. Perhaps, in addition, quality tolerances are so close that deviations in operating conditions will degrade the product. In such instances careful consideration of the controllability of each piece of equipment is in order. Otherwise, larger, more costly, margins of safety, or, shall we say, margins of control will be required in the equipment. Otherwise, additional capacity may be required for reprocessing. Otherwise, needlessly expensive and complex instruments may be required to offset poor equipment design.

Probably it will be news to many that outlay for industrial instrument equipment may reach 10 percent of the total outlay for a plant—or much higher percentages on individual pieces of equipment—and still be handsomely justified. In other instances an outlay 1/10 or even 1/100 as great may be beyond the economic limit. The decision will be up to the process engineer in charge—plant designer, project chief or whatever his title—the man who is expected to do with one dollar what any fool can do with two. He may delegate much of the detail to process and instrument specialists, but not the decisions, since they are essentially economic and should be thoroughly integrated with the economics of all other technical and personnel factors of process design, plant layout, and equipment selection.

The exact procedure will vary considerably with individuals and with problems, but in one way or another, by analysis or by analogy, the steps are approximately as follows:

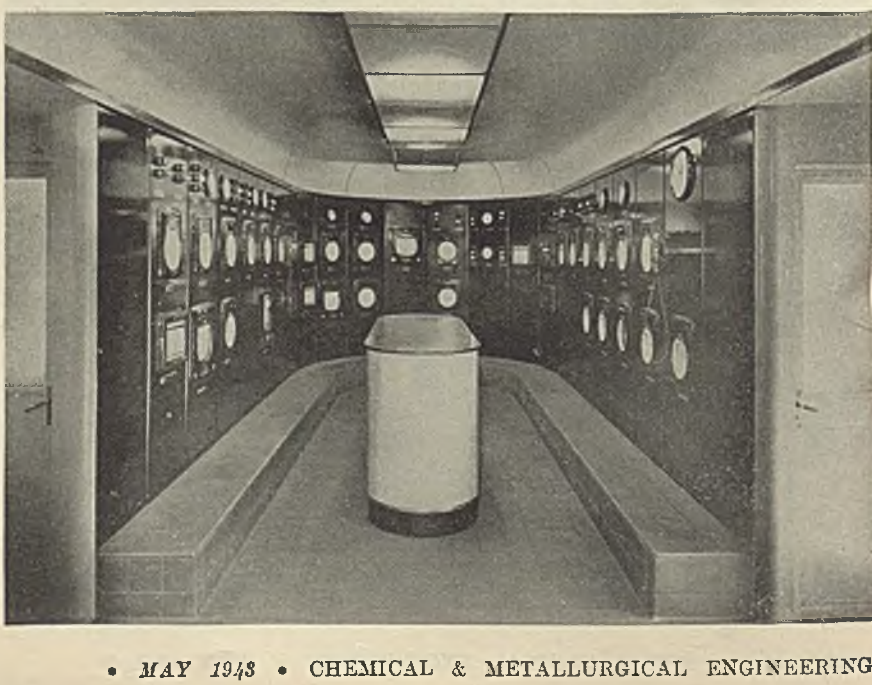
- List all process variables
- Define magnitudes and timing of variations
- Evaluate control effects, direct and indirect
- Settle on measurements and control of primary variables
- Settle on measurements of important secondary variables.

The first three steps are a collection and ordering of operating data for the subsequent decisions. A complete listing of all process variables requires both a general understanding and a detailed knowledge of the process and/or equipment to be controlled. Collaboration between process and control specialists starts here, often with the consideration of possible short-cuts in the task. Much time can be saved by drawing on experience for analogous situations, but when this is done, great care is necessary to see that significant differences are not overlooked. Changing a process from batch to continuous operation introduces a great many new variables concerned with rates of flow. Building a new unit out-of-doors exposes pipes and equipment to sudden chilling from rain (evaporative cooling) which is never encountered indoors. Significant variables also may be overlooked if under newly changed conditions, factors habitually omitted from consideration as negligible, are no longer negligible. Turning the process unit out-of-doors subjects equipment to ambient temperatures of −30 to +120 deg. F. instead of 60 to 90 deg. F. Substituting materials in construction may result in rapid change of heat exchanger and pump characteristics from corrosion. Substituting process materials may result in sludging, scale, or corrosion not formerly met. Even omitting chlorination of cooling water may introduce large variables from sliming.

The magnitudes and timing of process variables must be carefully considered. Changes in scale of a process from laboratory, to pilot plant, to commercial scale plant are often most significant since surfaces vary as the square of the linear scale factor and masses and volumes as the cube. Changes in design resulting from or made to compensate for the change in scale introduce further factors affecting process evaluation.

The evaluation of the control effects of the variables can be accomplished in various ways. An experienced and observing process man will be able to say what will happen under conditions within his experience, but may feel lost outside the field of this experience. A control engineer may be fully familiar with the theory of control and the effects of energy storage and energy transfer lags, but he will have difficulty unless he has sufficient process experience to develop his judgment of the quantitative factors in control applications. Collaboration is necessary.

Fig. 2—Colonial Beacon Oil Co.'s control board at the Everett, Mass., refinery



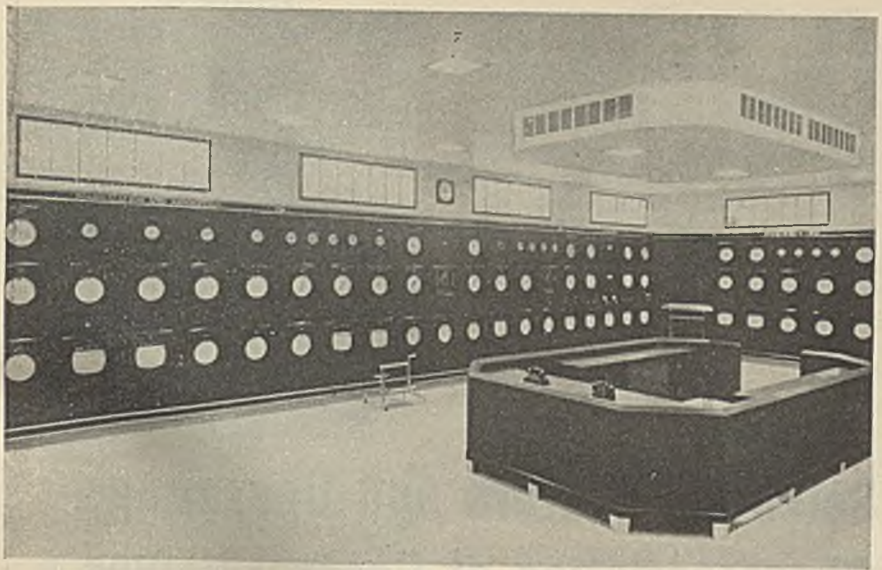


Fig. 3—New plants often have involved several hundred industrial instruments

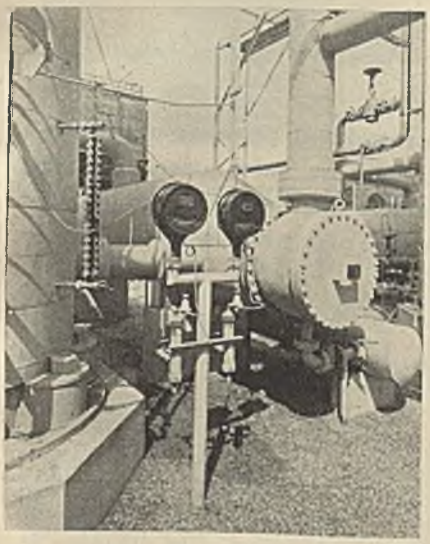


Fig. 4—Outdoor installation of pneumatic transmitters at petroleum plant

Process operation having been thoroughly evaluated, the next step in control is to select the primary, or independent, or causative variables, and settle upon methods of control for each of them. In modern practice this means to record and automatically control these variables.

Often it may not be immediately obvious which are the primary variables. In a batch neutralization, for example, pH is the primary variable; but the same pH measurement made in the same way with the same equipment is a secondary variable in a continuous process. There the solution flows and concentrations are the primary variables. Only when the primary variables have all been controlled, would control of the secondary variable, pH, become significant and subject to consideration as an operating variable.

In general, there are two approaches—more and/or larger equipment to give plenty of margin of control, or more instrument equipment. The trend is toward more and more outlay for instruments because the total outlay for a given plant capacity is less. Of course, the better the controllability of the equipment itself, the less instrument equipment will be needed. Too often, not much thought has been given to designing or selecting equipment for controllability, and especially for instrument control where the equipment may not function in the same manner as for manual control. Let us repeat that automatic control is continuously attentive, but unreasoning. It should be arranged to sense and correct for each tiny deviation in each variable, rather than to make accumulated end corrections for various deviations. Within economic bounds, it is preferable to take care in the selection of equipment, and then to use the simpler forms of control when possible, rather than to try to compensate for poor controllability of equipment by more complicated forms of control. Nowhere is this better exemplified than in temperature control applications. There the process lags may be large and complex, and the undesirable process effects of inadequate control correspondingly serious. The papers by Haigler and by Bristol and Peters are especially pertinent to planning for controllability in heat processing (see references).

In all these studies, the question how best to measure certain variables and control them automatically will arise again and again. Here a knowledge of what instrument measurements are practical under the existing conditions is essential. Also when a desired measurement cannot be made directly, process knowledge may be necessary to search out related variables which are significant or may be made significant by establishing suitable conditions. In the continuous neutralization problem mentioned above, it may not be possible to measure and control the reacting concentrations directly, but specific gravity or electric conductivity might be a suitable measurement if temperature were kept constant. If not, it might be necessary to go back still further in the process and establish conditions assuring stable concentrations.

In short, collaboration of control and process knowledge must continue in the instrument as well as the process part of plant design for controllability. For process people who seek theoretical and descriptive background on instruments and control, perusal of the references listed at the end of this article will be helpful. Reading catalogs and discussing problems with capable vendors' representatives—taking reasonable account of commercial bins and reputation—are obvious and often worthwhile approaches. For instrument specialists seeking process knowledge, actual operating experience is best, although "case studies" and work on hydraulic, pneumatic or electronic process simulators undoubtedly will become an increasingly important part of training. Discussions with experienced operating men and process engineers are always worthwhile. In time, of course, we may expect controllability to become a part of the training in theory, design and operation, just as economic considerations have come to permeate training whether in professional schools or foremanship courses, and whether taught as a specific "course" in economics or not.

In the mathematical terminology, control of the primary variables is a "necessary" but not a "sufficient" condition to successful process operation. When control is provided for the primary variables it is still necessary to know how to set operating conditions to meet quality requirements. Measurements of the other or secondary variables provide the data for determining these settings.

Before the wide usage of recording instruments, log sheets were depended upon, but any operating man knows their limitations. At best, logs require conscientious regular attention of a busy operator, often several operators, if reasonably frequent and simultaneous readings are desired. Data are no better than the inadequate and often inaccurate instruments usually associated with the log system of operation. Often data must be laboriously plotted before it is useful. At worst, logs are dull fiction.

Now, in the modern plant, accurate, complete, simultaneous plots of the variables against time—instrument chart records—go a long way toward providing the "reasoning" to guide the setting of the attentive but unreasoning automatic controllers. The charts show the trends, the deviations, and the rates of change, whence the necessary corrections are almost self-evident. When trouble arises from erratic or unsystematic or inconsistent behaviour of equipment of operators, recording instruments are of peculiar assistance in reestablishing stable operations. Recording instruments are likely to be well engineered and installed, and hence capable of accurate and significant measurements. Recording instruments are not likely to be manipulated to produce fictitiously fine charts, not so much because it cannot be done, but rather for the reason that the instruments give the operators so much constructive operating assistance that the process difficulties can be quickly identified and remedied.

SUMMARY

In the final analysis the control of a chemical process or a process unit is a problem in engineering economics. Each part of the investment in process equipment, including instruments, must be justified, like any other capital and operating expenditures on the basis of its contributions, tangible and intangible, to the production of a saleable product at a suitable cost.

A reasonable balance must be struck between great refinement of accuracy and completeness of control which makes for ease in operation, but at considerably increased investment, and neglect of control which leads to constant loss from operating troubles and degraded product. This balance is best attained where there is careful study of controllability starting with process development, continuing through plant layout, and carried through to the details of equipment selection.

The procedure for evaluation of controllability is similar whether it involves a whole plant or a single piece of equipment. A full knowledge of the process must be developed by listing all process variables, defining the magnitudes and timing of the variations, and evaluating the control results. Then the primary (or independent or causative) variables must be controlled, usually by recording controllers, while important secondary (or dependent or resulting) variables must be measured, usually by recorders.

The selection of the instruments should be carried out in conjunction with, not following, process development, plant layout, or equipment selection. Controllers are continuously attentive but unreasoning, and hence cannot be best applied like manual control. Recorders are needed to supplement controllers by plotting continuous simultaneous records of the variables against time so that trends are shown and necessary process and controller settings become almost self evident.

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Selection Factors and Operating Characteristics of Control Valves

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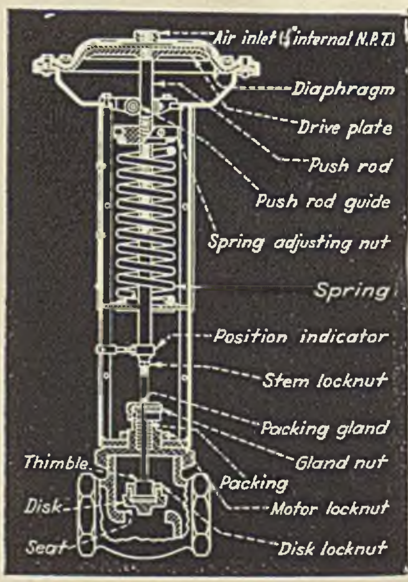
For proper operation of automatic control valves, certain desirable characteristics must be incorporated into the valve assembly. The author discusses herein selection factors and those characteristics that have the most influence on the overall performance and reliability in the automatic control of fluids.—*Editors.*

THE TIME has long since passed in the automatic control of fluids when the control valve is merely a nondescript accessory to the controller itself. Certain desirable operating characteristics must be incorporated into the valve assembly, which consists of both control valve and driving mechanism or motor. Each of these components affects overall performance and reliability and, therefore, must be considered jointly. Furthermore, in the interest of simplicity, this discussion will be devoted to a so-called diaphragm motor type of valve requiring a compressed air supply for its actuation, this supply being apportioned to it by a controller responsive to changes in temperature, rate of flow, pressure, or other variable.

Fig. I represents a typical diaphragm motor valve. Before discussing factors affecting its performance, we should first define the purpose the valve serves in the control circuit. Stated briefly, its main function is to serve as a variable orifice in the controlling medium supply whether this be water, steam or gas. Granting that this function must be accomplished, then the factors which should first be considered are those which determine the position of the disk for a given output of air pressure from the connecting controller.

Diaphragm motors consist essentially of a flexible rubber diaphragm which is subjected to the controller output pressure. Opposing the force produced by the diaphragm is that which is produced by a spring. The difference in

Fig. 1—Cutaway view of diaphragm motor operating an air-to-close valve of beveled disk type



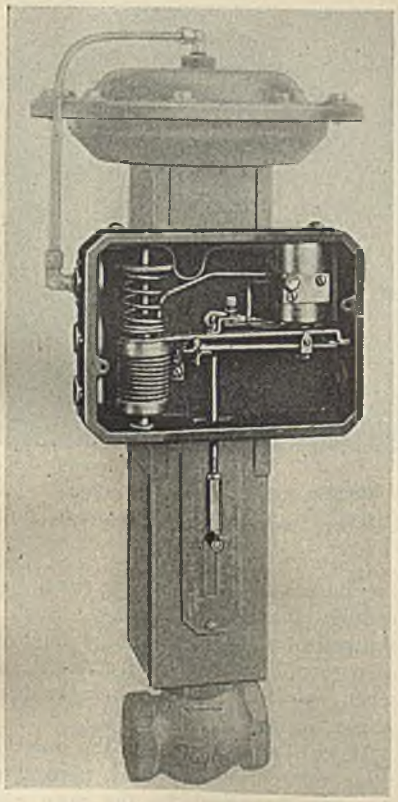


Fig. 4—Diaphragm motor equipped with valve positioner

these forces represents the energy available to overcome the effects of valve stem friction in the packing box, the upward thrust of the disk due to line pressure, as well as the side thrust of the spring itself.

A well-designed motor, therefore, is one that is capable of producing a net driving force adequate to overcome the effect of friction to the greatest possible extent. This is accomplished by employing relatively stiff springs and large effective diaphragm areas as well as a suitable stem guiding means. At best, a hysteresis (a general term including all frictional forces) of approximately two percent exists under ideal conditions and usually this will run up to a considerably higher value, depending upon the condition of the packing around the stem which resolves itself into a matter of maintenance. Fig. 2 graphically shows disk position plotted against ascending and descending controller output air pressures. Such performance is satisfactory for a large percentage of applications of the not-too-difficult type, i.e., when process lags are relatively short and thermal inertia or capacity effects are large.

Likewise, the flow characteristics of the valves, which will later be discussed in detail, become relatively unimportant in this class of application (since the controller sensitivity will be sufficiently high to give a large corrective action for a small change in controlled medium). Fig. 3, showing a hysteresis of 17.5 percent of total travel, is indicative of the depreciating effect on valve performance which can occur when a stuffing box is tightened excessively as is often done when an attempt is made to stop leakage around the stem instead of repacking. Another performance requisite in diaphragm motor operation is that there should be a linear relationship between valve stem movement and actuating air pressure. Such a result is achieved in well-designed diaphragm motors by maintaining a constant effective area throughout the usable travel of the valve stem with due consideration to spring characteristics.

VALUE OF VALVE POSITIONER

Before extending this analysis to the design of the control valve itself, it is evident that further perfection must be obtained in the functioning of the diaphragm motor. As will be described later, certain forms of control valves are equipped with so-called characterized ports designed to give a definite flow change for a given small increment of disk travel. If the inherent amount of friction in the driving mechanism is great enough, it is clear that small changes of air pressures applied to it do not cause an equivalent response in stem movement, thus modifying the intended flow change. Such a condition is detrimental to accurate control, especially on difficult processes and it is for this reason that valve positioners have been developed. By means of this type of device it is possible to position the valve stem and disk more accurately than is possible with any unassisted diaphragm motor.

A valve positioner as shown in Fig. 4 is in reality a pneumatically operated position controller which forces the valve stem and disk to go to their correct position. The air pressure from the controller is not connected to the diaphragm motor, but is connected to a bellows which positions a baffle. A nozzle which actuates a relay air valve supplied from an auxiliary source of compressed air is attached to the valve stem and disk. Unless the nozzle is in correct operating relationship to the baffle, the diaphragm motor is either inflated or deflated until the valve stem and disk assume the correct positions.

Therefore, even though there might be a considerable diaphragm valve hysteresis, the valve will assume a position corresponding to the end of the baffle. By this method very accurate positioning of the valve stem and disk is provided, the hysteresis being reduced to a negligible amount, as indicated in Fig. 5.

Diaphragm valves in most common use can be divided into three general classes, namely, (1) air-to-close or direct acting; (2) air-to-open or reverse acting; (3) three-way. The first two can be further sub-divided into single and double seated types. These are illustrated in Figs. 6 to 13 inclusive, and are adapted for general liquid, steam and gas service. Body and trim materials are available to make them suitable for a variety of corrosive and erosive applications although present wartime restrictions necessitate the employment of ferrous materials wherever possible.

TYPES OF VALVE BODIES

Many other types of diaphragm-operated valves for specialized applications are also available. To mention a few, there are:

(1) Butterfly valves for low pressure drop service;

(2) Sanitary valves for milk, citrus juices, and other food products;

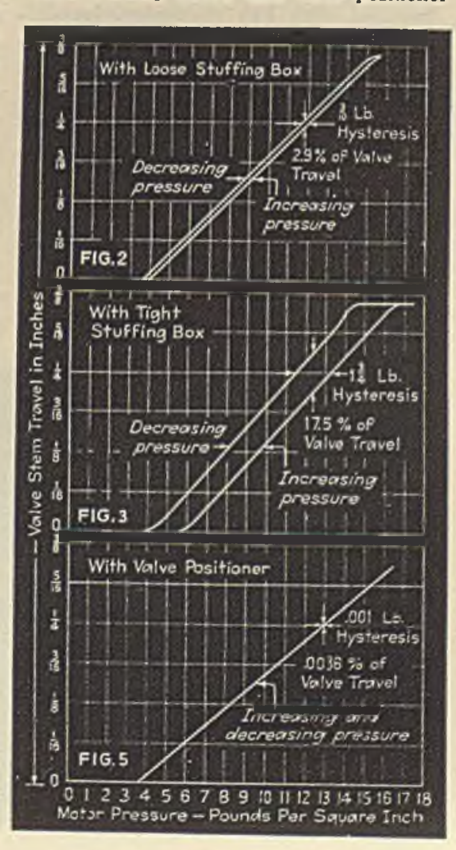
(3) Proportioning valves for two-pipe burner systems;

(4) Packless valves of the Saunders type for extremely corrosive substances and slurries;

(5) Automatic two-pressure valves for hydraulic use.

In general, diaphragm-operated valves are practicable in one form or another in sizes from 1/8 in. to 24 in.

Hysteresis curves for diaphragrm valves with stuffing boxes and with positioner



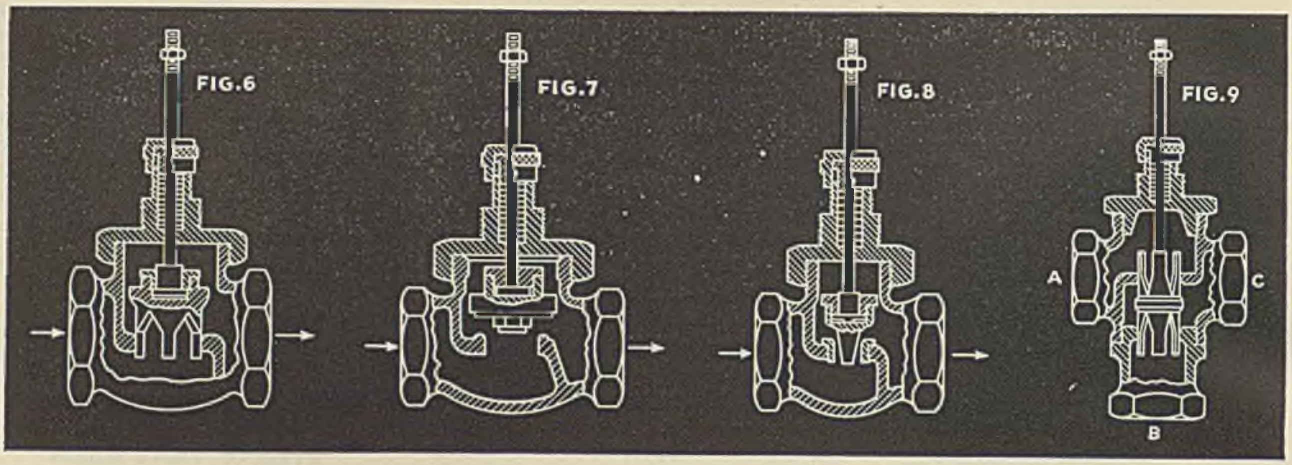


Fig. 6—Single seat, V-port air-to-close valve
Fig. 7—Composition disk, single seat, air-to-close

Fig. 8—Needle valve, air-to-close type
Fig. 9—V-port single disk, three-way valve

and for pressures up to 5,000 lb. per sq. in. for the smaller sizes.

FLOW-LIFT CHARACTERISTICS

A variety of shapes of disks have been developed for control valves in order to achieve certain flow-lift characteristics. The so-called bevelled type has been in use a long time. In common use also are needle valves for small flows which can be considered in the bevelled type class. Fig. 14 shows the relationship between flow and disk lift for a condition of constant up and downsteam pressure. The scale units are arbitrary and are intended to show only the relative proportion of flow and travel. It will be noted that the bevelled disk has characteristics differing from the others shown. It possesses a substantially linear flow-lift relationship from zero to two units of travel. For the small remainder of its travel its change in capacity drops off sharply. It can be concluded, therefore, that this type of valve is useful over a fairly wide range of flow, including low rates of flow when the disk is moved but slightly away from its seat. Also, its total capacity is greater than that of the other types shown, particularly the ratio plug.

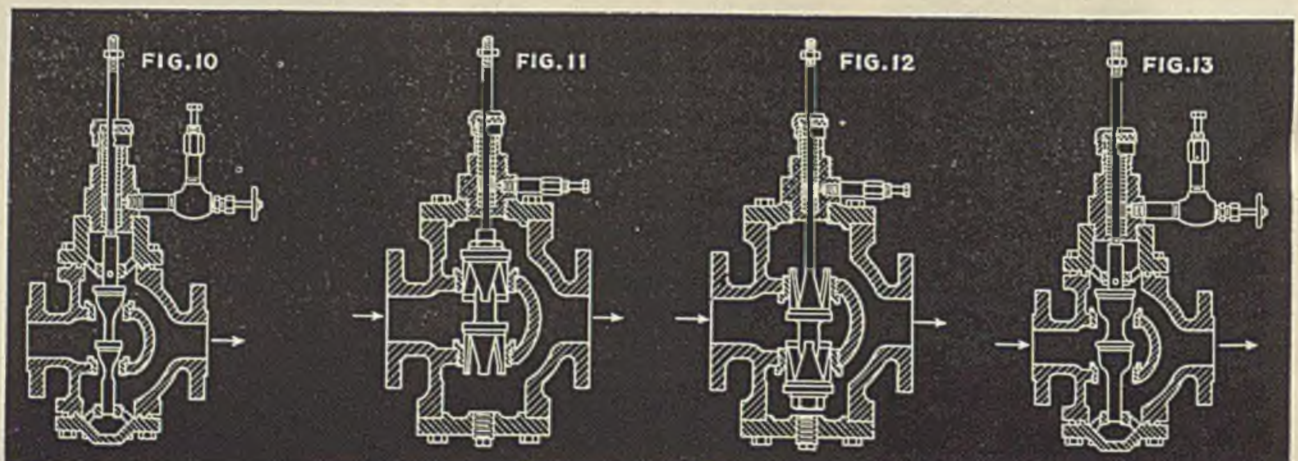
Compared with the other types shown, its flow-lift characteristic is quite different. For example, for a travel of 0-0.25 of a unit, it will pass 30 units of flow while for the same increment of travel between 1-1.25 units it will pass but 10 units. This characteristic, under certain restricted operating conditions, can prove detrimental and has lead to the development of various forms of disks or plugs of the so-called percentage type.

Ratio plug and throttle plug type valves are similar to those in Fig. 13. V-port type valves are constructed as shown by Figs. 11 and 12. These are of the percentage type and have been developed in an effort to provide a means of furnishing equal stability at all loads with the same controller sensitivity. Their flow-lift characteristics are intended to be such that equal increments of lift will give equal percentage increments of flow. Such a theoretically ideal percentage relationship would appear as a straight line when plotted on semi-logarithmic paper, as shown in Fig. 15.

It will be noted that in the order of their adherence to equal percentage flow-lift characteristics the ratio plug ranks first, the throttle plug second, and the V-port disk third. The curves reveal a further characteristic known as "clearance flow." This represents that portion of the total flow which is not controllable by the initial increments of disk travel. Here again there is non-uniformity arising from necessary clearance between the seat ring and disk to prevent seizing and to allow reasonable manufacturing tolerances. In this respect that shown for the V-port is 2.5 percent, for the throttle plug 4.5 percent, and for the ratio plug 6 percent. This characteristic when expressed as the range factor is known as the *clearance flow.* For example, in the case of the V-port disk,

Fig. 10—Double seat, throttle plug valve, air-to-close
Fig. 11—Double seat, V-port valve, air-to-close

Fig. 12—Double seat, V-port valve, air-to-open
Fig. 13—Double seat, ratio plug, air-to-close



the range factor is 100:2.5 or 40. Because clearance flow increases as the diameter and the total flow increases as the square of the diameter, large valves have larger range factors. In valves smaller than one inch, singe-seated types are necessary if a large range factor is desired.

ACTION OF CONTROLLER

Before attempting to arrive at an overall evaluation of the importance of valve characteristics in the control system, it is necessary to examine the effect exerted by the primary actuating device or controller.

To illustrate this relationship, Fig. 16 has been prepared, consisting of two adjoining graphs. The two curves in the upper portion represent typical controller air output values. Those for controller *A* are non-linear while those for controller *B* are linear. The lower graph depicts the flow-lift characteristic of a percentage value of the ratio type on semi-logarithmic coordinates. The dotted lines connecting the upper and lower portions show the relationship between the output change of each controller and the change in percentage of flow for a 2 deg. F. change in the bulb temperature of a controller at separated temperatures. (This example is analogous to a temperature or pressure controller having a fairly low sensitivity, i.e., one in which a large change of the controlled medium produces a relatively small change in valve position.)

This graph makes apparent several interesting points. Controller *A*, as a result of a 2 deg. F. change between 9 and 11 deg. F., causes a change of 31 percent in the quantity previously passing through the valve at 9 deg. F. This same 2 deg. F. change between 17 and 19 deg. F. causes a 72 percent flow change. Thus, it is apparent that the non-linearity of a controller can practically nullify the percentage characteristic of the valve which it is operating. If, for comparison, we similarly analyze the action obtained from controller *B* having linear output characteristics, we obtain values of 35 percent and 45 percent. The percentage of flow change should be equal for all increments of temperature change if a true percentage relationship is to exist. It is obvious that a linear controller output assists in realizing this ideal, but in practice, it may not completely fulfill it because of the possible small departures from the theoretically perfect shape of the plug itself.

It is equally apparent that the non-linear output characteristics of a controller, such as *B*, practically eradicate the flow-lift relationship which may exist in the control valve.

The flow-lift characteristics of valves as has been previously discussed, are influenced by:

(1) The diaphragm motor pressure-travel relationship;
(2) Mechanical hysteresis of valve and motor;
(3) Controller output linearity;
(4) Plug or disk shape.

EFFECT OF PIPING

To these there must finally be added the effect on characteristics produced by improper installation. Since in any control circuit the valve acts as a variable orifice, precaution should be taken to make certain that the pressure drop actually occurs across the disk and seat for all rates of flow within the capacity of the valve. Percentage type valves usually have maximum capacities less than their equivalent pipe size and, therefore, may perform satisfactorily when connecting piping is of the same size and comparatively short, such as 50 pipe diameters. It is usually good practice, however, to employ connecting piping one size larger than the valve body ports call for since this has the effect of confining the pressure drop at the valve disk with the result that the flow characteristics of the valve are preserved, thereby enabling the flow to change exactly in accordance with the dictates of the controller itself.

Fig. 17 shows graphically the effect of using correct and incorrect piping with a valve having a good characteristic. One curve shows the relationship of flow to lift for a one inch valve alone with a constant pressure drop of 20 lb. per sq. in. Another curve shows the flow-lift relationship for the same valve installed in a 30 ft. length of $1\frac{1}{2}$ in. pipe with a 20 lb. per sq. in. drop across the whole installation. It is seen that the curve retains its shape and loses only slightly in capacity at full lift. The third curve clearly shows the restriction in capacity and the loss of characteristic caused by the use of one inch pipe with a one inch valve. Although the length and pressure drop are the same as for the $1\frac{1}{2}$ in. pipe, the capacity is only 58 percent of the valve capacity and the characteristic has been modified considerably.

Incorrect sizing of valves perhaps more than any other single factor can contribute to poor overall performance of an automatic control system. Too often over-size valves are selected due either to an improper analysis of the conditions under which the valve is to operate or to a lack of knowledge of the true capacity and flow-lift characteristic of the valve being selected. Most manufacturers specializing in the control valve field have developed size selector charts which can be depended upon within an accuracy of plus or minus ten percent.

VALVE SIZING

Two factors are of principal importance when sizing a valve. First, make certain that the pressure drop used in calculating the size agrees with that which will actually exist in service. In this connection, it is a fallacy to select a control valve on the basis of minimum pressure drop, as is the practice when calculating pipe sizes to keep the flowing medium from exceeding specified maximum velocities. Valves sized on this theory will be excessively oversize and if usable at all, will penalize overall performance due to requiring a controller sensitivity abnormally low for the process. This in turn leads to wide deviation in control point when load changes cause a disturbance.

It is axiomatic that the control valve must create a pressure drop of the magnitude necessary to restrict the flow to the quantity called for by the controller and that for all port areas there must be sufficient driving force in the form of pressure drop to assure adherence to the flow-lift characteristic of the valve. Secondly, maximum and minimum flow rates should be well within the linear portion of the valve's flow-lift curve. When this cannot be accomplished, the

Fig. 15 — Flow-lift characteristics of valves on semi-logarithmic paper

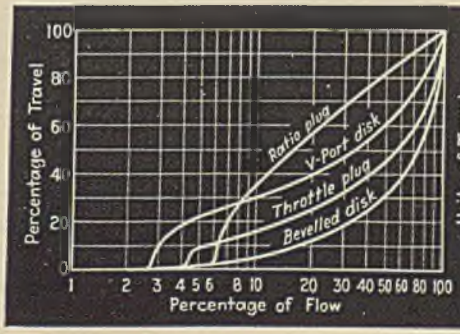
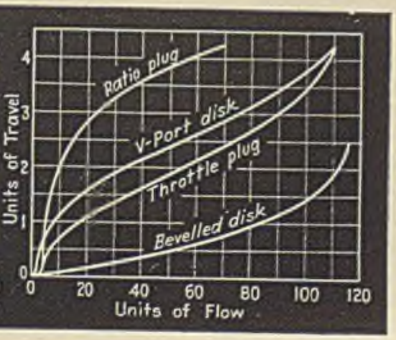


Fig. 14 — Flow-lift characteristics of valves on rectangular coordinates



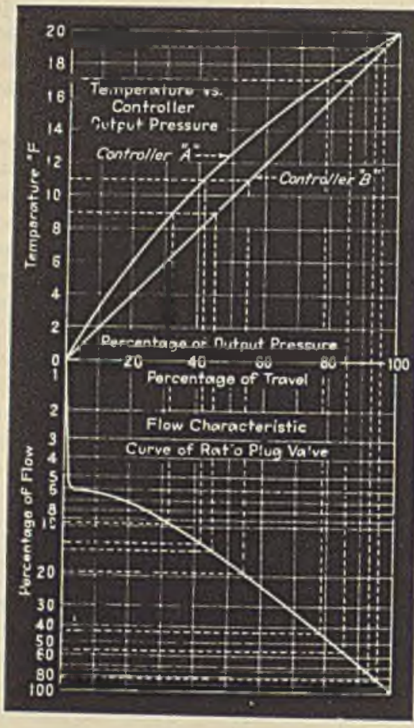


Fig. 16—Relationship of controller output to percentage type flow-lift control valve characteristics

use of two valves is recommended and these should be arranged so that slight overlapping exists between them. Such an arrangement also is beneficial as a means of reducing the destructive effect of erosion or wire drawing which is accentuated when two seating surfaces, subjected to high velocity effects, are brought close together.

APPLICATION CONSIDERATIONS

In the final analysis, the valve must be mechanically reliable. A minimum of trouble can develop with a bevelled disk type valve since there are no small clearances involved in its design. Its disk simply moves away from its seat through the influence of the stem.

V-port valves are also generally dependable. With this type of valve there must be adequate clearance between the seat ring and skirt to avoid seizing, particularly at elevated temperatures. Its flow-lift characteristic remains fairly uniform over long periods since narrow openings are avoided, reducing the effect of wire drawing on the disk and seat.

Plug type valves are increasingly difficult to manufacture and maintain, the closer the design approaches a true percentage flow-lift relationship. This is because of the extremely accurate machining and close clearances necessary. Where the controlling medium is exceptionally erosive, corrosive or deposit forming, this type of valve may not long retain its original flow-lift characteristics and develops a tendency to stick. For these reasons, plugs of the throttle type which depart further from the percentage flow-lift relationship and which do not, therefore, of necessity have to be held to such close tolerances in manufacture are used extensively.

It can be concluded that only under certain specific conditions does the flow-lift characteristics of the valve become an important element in a control circuit. Valves of the so-called characterized type are not necessary for temperature and pressure control where the process can be dealt with by a high sensitivity (narrow throttling range) controller. Such processes involve those possessing a small lag in relation to capacity.

CONTROLLER AND PROCESSS

Where both the lag and capacity are small in a process a low controller sensitivity (wide throttling range) must be used which makes it advantageous to equip the valve with a positioner. Otherwise the mechanical hysteresis of the valve assembly would necessitate an appreciable added output pressure (and consequent temperature or pressure) change to overcome the effect of friction. In this case, the contribution of any specialized flow-lift characteristics would be secondary to the accomplishment of accurate positioning of the stem and disk so as to obtain a flow change highly responsive to minute controller output changes. This holds equally true for long time lag processes where the load change is small, in which case the valve is not required to change its position through but a small fraction of its stroke.

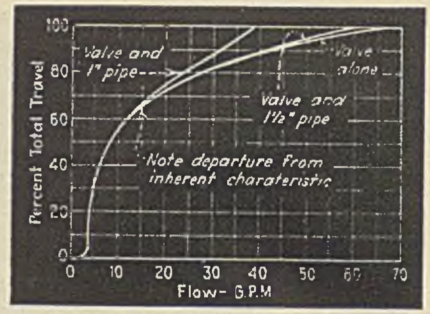


Fig. 17—Effect on flow-lift characteristics using 30 ft. of one in. or one and one-half in. pipe with one in. ratio plug valve

Use of valves possessing percentage type flow-lift characteristics becomes an asset primarily on those applications involving a combination of long time lag and large load change. However, as has been graphically shown (Figs. 4 and 16) two other conditions have to prevail (neglecting friction within the controller mechanism itself), namely, precise disk positioning and linear controller output before the percentage flow relationship of the valve is approximated in response to controller output changes. On this class of application, valve characteristics should be considered if through them it is possible to obtain more nearly equal stability at all loads with the same controller sensitivity. It would appear that percentage flow-lift characteristics are nearly ideal when the major source of load change is due to variation in the pressure drop across the valve or in the heat content of the controlling medium passing through the valve.

Likewise, valves with good percentage flow-lift characteristics are advantageous for use with flow controllers. It can also be said that linear characteristics are well suited for certain applications, such as liquid level control. Many applications can conceivably call for specialized characteristics (J. C. Peters, *Ind. & Eng. Chem.* 33, 1095-1103, Sept. 1941).

The accompanying table summaries in brief form conclusions which can be derived from the foregoing discussion. The heading "reset" refers to automatic controller reset response which becomes increasingly necessary in direct proportion to the severity of operating conditions.

Relative Importance of Valve Characteristics to Process Conditions

	Load Change	Reset	Valve Positioner	Valve Characteristics
Lag Small Compared To Capacity High Controller Sensitivity	Anything	No	Not Important	Not Important
Lag Small Small Capacity Low Controller Sensitivity	Anything	Yes	Relatively Important	Not Important
Long Lag Low Controller Sensitivity	Under 2/1	Yes	Important	Not Important
	Over 2/1	Yes	Important	Should Be Considered

Pneumatic vs Electrical Automatic Control

E. L. STILSON

Assistant Sales Manager, The Bristol Co., Waterbury, Conn.

In determining, from an unbiased standpoint, the type of control to be used, it is necessary to analyze the process, the variables which must be controlled, to assure the best results, the comparative overall costs and the surrounding or secondary conditions.—*Editors.*

THE TERM "PNEUMATIC CONTROL," as used hereafter, refers to that type of control where the controlled valve, damper, piston or prime mover controlling a variable in a process, is actuated by compressed air or gas, the pressure of which is controlled by a measuring instrument. The term "electrical control" refers to that type of control where the controlled operator is actuated electrically by a measuring instrument. Self-actuated, hydraulically operated, and other types of control are not considered here. Industrial measuring and controlling instruments of the two types under discussion are all torque amplifiers, the power of compressed air or gas actuating the pneumatic operator, or the power available at the operator in the electrical type, being many times that of the measuring instrument itself.

The principal variables encountered in industrial processes to which measurement and control may be applied, may be considered as pressure, temperature, flow, liquid level, speed, motion, pH, specific gravity, conductivity, gas analysis, voltage, current, watts and other electrical quantities. Other variables such as viscosity, color, etc., are, of course, being taken into consideration more and more.

The function of any industrial controller is to control at some fixed value a variable which otherwise would influence unfavorably the process involved. It would not make sense to attempt to control a constant, although sometimes the attempt is unthinkingly made.

All men have unconscious prejudices. They tend to favor that with which they are most familiar. If the instrument selections are in the hands of an electrical man, he may tend to select electrical control. If the user is accustomed to pneumatic control, he will tend to select that type of control. All instrument manufacturers are familiar with specific industries which lean either toward electrical or pneumatic control due to a general tendency of thought within the industry.

In determining, from an unbiased standpoint, the type of control to be used, it is necessary to analyze the process, the variables which must be controlled, to assure the best results, the comparative over-all costs and the surrounding or secondary conditions. By the last is meant conditions peculiar to the individual application. There are instances such as where no constant source of electric current is available, as in gas fields, but where the presence of gas under pressure supplies a means of readily operating pneumatic controllers. In the case of an electric furnace where contactors are operating, an electrical control system naturally is first considered.

Electrical control may be said to have anticipated pneumatic control, in that it was readily applied to many batch processes in a very simple form. The first electrical controls often merely made one or two contacts, which caused a valve to open or close, a relay to operate, etc. Electrical controls of this type are still widely and effectively used on many applications where they are entirely suitable, such as ovens, some furnaces, etc. With refinements in the method of measurement, and additions of two- and three-point control, high safety contacts, fail safe devices, etc., they are still fundamentally descendants of the early, simple contact making off-and-on electrical control.

The development of continuous flow processes in particular has caused the pneumatic control to assume increased importance. Modern petroleum refining and other continuous chemical processes introduced such problems as time lag and load change, which the manufacturer of pneumatic controllers found necessary to take into consideration. This prompt understanding of the requirements by the instrument manufacturer was of great value in the operation of continuous processes. Modern continuous processes, where

Balancing the advantages of one type of control system against another

	Pneumatic Control	Electrical Control
Actuating medium.....	Requires constant supply of clean, dry air or non-corrosive gas.	Requires constant electrical supply at proper voltage.
Corrosion resistance of measuring instrument	With a well designed instrument case, corrosion is a minor factor	In corrosive atmosphere requires tight instrument case and possible air purge to prevent corrosion of slide wires, ontacts, etc. Special alloys necessary for contact making parts
Controlled valve or operator	Valve operator simple and usually easily handled by maintenance men	Valve may require explosion proof construction for explosive atmosphere and is generally more complicated. For large, hard to operate valves, more starting power available to seat or unseat
Valve or operator position	Finite number of steps	Infinite number of steps
Distance from instrument to valve or operator	Limited	Unlimited
Safety	Excellent if properly selected	In hazardous atmosphere may require explosion-proof or explosion-resistant construction of certain units. Instrument may require air purge of case.
Original cost	Dependent on type of instrument. Usually less on complete installation	Dependent on type of instrument
Operating cost	Energy cost more	Energy cost less than for pneumatic. In general, cancelled out by greater maintenance cost
Installation cost	Dependent on type of installation. If compressed air or gas not available, may be higher for small installations due to compressor costs	Dependent on type and installation. May be lower where distance between instrument and valve or operator is considerable and wiring not elaborately housed
Ease of maintenance	Dependent on type of trained help available and familiarity with pneumatic systems	Dependent on type of trained help available and familiarity with electrical principles

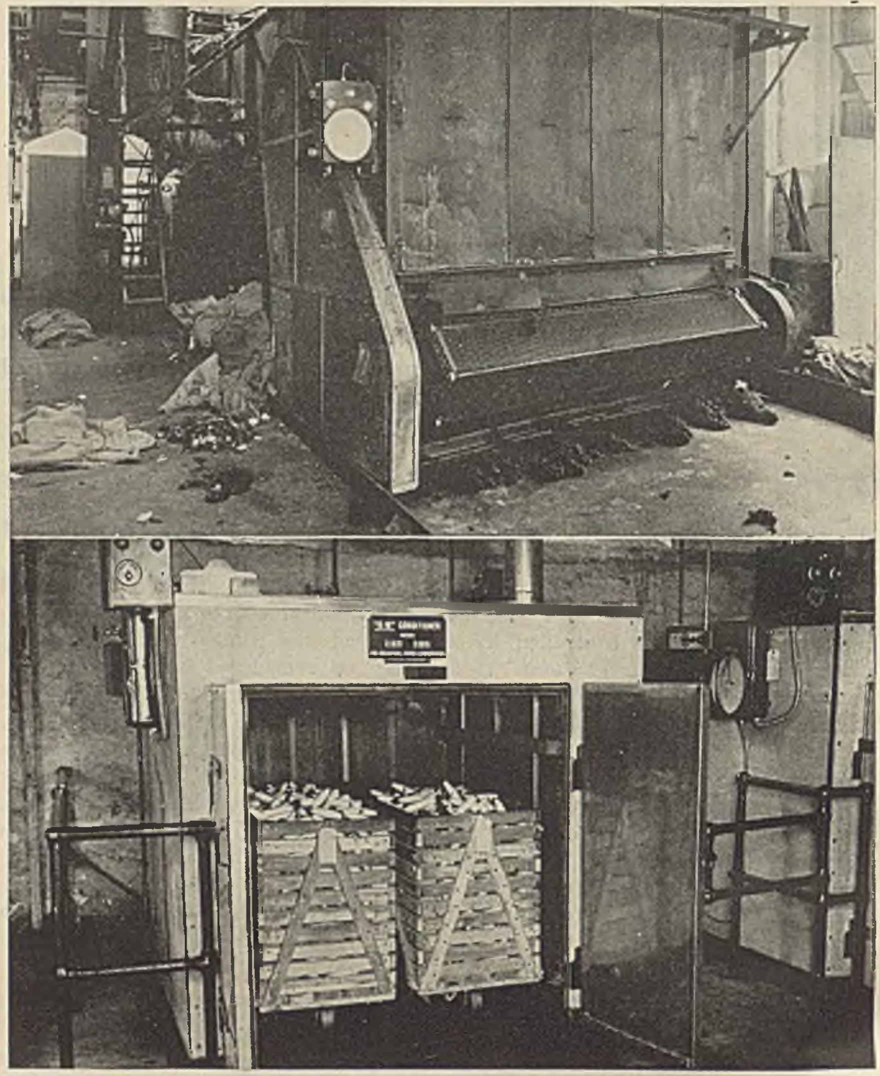
temperatures, pressures, etc., are often extremely critical, are in most cases now centered about automatic control without which process operation would in many cases be impossible.

The manufacturer of electrical controllers has as a rule focused his selling efforts on somewhat different types of industries than the manufacturer of pneumatic controllers. The iron and steel industry and to a great extent other metallurgical industries, being electrically minded industries, have used electrical controls extensively.

The petroleum, chemical, and textile industries may be cited as among those which have tended toward pneumatic control. The dairy industry, in the pasteurization of milk, represents a process which was originally a batch type, using both electrical and pneumatic control, then became a continuous type, still using both electrical and pneumatic, but in which the trend toward pneumatic control, before the outbreak of war, was evident to everyone.

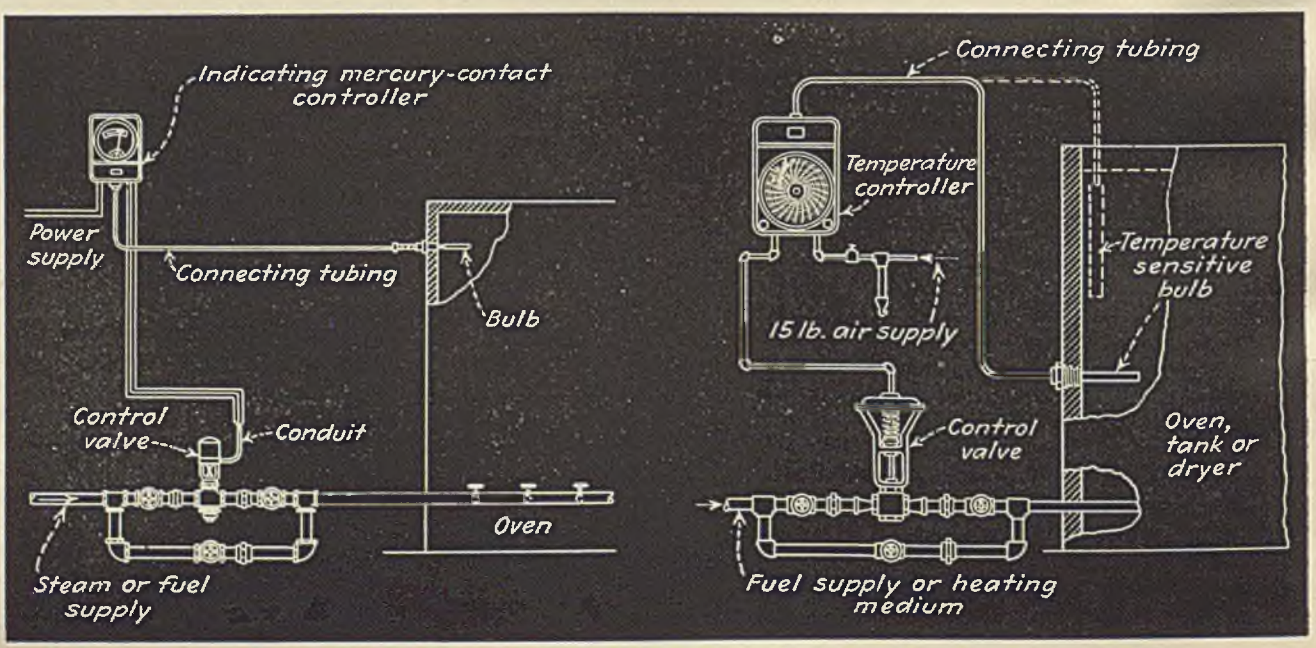
The advantages of advanced pneumatic control which have peculiarly fitted it to continuous processes, are the relative simplicity of such features as wide throttling range, automatic reset, and other readily adjustable functions which can be used to tune it to the lag, load, and rate of change. There are on the market a number of electrical control systems incorporating these same features, which are generally, however, used in industries already electrically minded rather than in those pneumatically minded.

Certain processes, by their very



Upper view shows a pneumatic recorder-controller on a large continuous dryer, while the lower shows an electrical controller operating on a small batch dryer

In many types of application the choice between electrical and pneumatic control depends on preference; an example is the control of simple tanks and ovens such as those shown below



nature, require combinations of both pneumatic and electrical control. So-called batch-continuous processes, in which at certain intervals in a continuous process a change-over is made, as from one catalytic case, reactor or adsorber, to another, are usually a combination of electrical and pneumatic, the pneumatic controlling the process between switchings, and the electrical controlling the switching sequence itself.

The hold which the pneumatic controller maintains on certain process industries is a challenge to the manufacturer of electrical controllers, and there is little doubt that the future will see some startling advances in type of control, especially with the rapid technological developments forced by wartime pressure. The pneumatic controller manufacturer, however, has by no means reached the end of his rope, and no doubt new developments now on the drafting board will result in pneumatic control systems capable of easily handling the most difficult processes.

The industry that has available both electrical power and gas or air under pressure is, of course, in a position to take advantage of the fact and select the type best suited to the application.

From an unprejudiced viewpoint, we may balance the advantages of one type of control system against another about as shown in the table on page 137.

Instrument Application Progress in Process Industries

EDITORIAL STAFF SUMMARY

Progress in the last ten years on applications of industrial instruments in the chemical and process fields has been outstanding, and within this period decided trends have been developing. In this section, representatives of some of the applications of interest will be summarized to serve as idea-producers for chemical engineers.—*Editors.*

In these six pages, Chem. & Met. editors present highlights of material extracted and concentrated from information supplied by the various instrument manufacturers. It is obviously impossible to include all applications of every instrument. An attempt has been made, therefore, to find typical as well as unusual and interesting uses. It is hoped that some of the ideas will be found applicable to the chemical engineering reader's problems.

TEMPERATURE AND PRESSURE

Automatic temperature control of polymerizers used for polymerization of butadiene and copolymers, such as styrene or acrylonitrile, presents a special problem. Simplicity of control with all possible elimination of hand adjustment is essential. Both The Bristol Co. and Taylor Instrument Cos. report an instrument has been developed to control the temperature of the polymerization.

The Buna S reactor temperature control system has a mercury actuated single duty bi-record instrument equipped with automatic reset. The temperature control bulb fits in a stainless steel well extending down into the reactor from the top. The controller actuates three control valves: steam, cold water, and refrigerated water. The reactor jacket is open, thus eliminating the necessity of a surge tank. Excess water overflows from the open jacket. The jacket water temperature is recorded by the second tube system of the instrument. The controller maintains the temperature at 125 deg. F., by controlling the admission of steam or cold water to the connected circulating system.

For each reactor there is also a recording pressure gage with a modified fixed high sensitivity mechanism for operating a double electropneumatic switch in an explosion resisting housing. If the pressure exceeds the set point, a light lights and a horn sounds, hence the double circuit. The special recorders are panel-mounted with the temperature control. Such instruments will undoubtedly find wide application in the synthetic rubber and plastics industries, as well as in other processes requiring polymerization reactions.

In byproduct coke plants, control systems for ammonia and phenol recovery processes respectively increase equipment capacity by increasing quantity of production yielded within a given time. Temperature of gas entering the saturator and pressure drop across the saturator are prime variables in ammonium sulphate production. Advantages of controlling the temperature of entering gas include: Prevention of excessive dilution of the saturator bath, prevention of clogging of lines due to condensation of naphthalene, maintenance of optimum temperature for reaction in the saturator, elimination of waste of reheated steam, and assurance of production of ammonium sulphate crystals of proper size. In the Brown control system, temperature is controlled by regulating the amount of steam flowing into the reheater and control of the differential pressure across the saturator is maintained by regulating the flow of make-up water.

The Brown system for controlling the operation of the ammonia still and the dephenolizer tower involves temperature control by regulation of steam, control of temperature drop across the dephlegmator, control of lime feed, control of pressure in a dephenolizer, control of sodium phenolate level, control of caustic flow to the dephenolizer, control of liquor level in sump tank, and instrumentation of miscellaneous variables. In the system, carryover of carbon dioxide and hydrogen sulphide into the dephenolizer is prevented, waste of steam is eliminated and load on ammonia vapor dephlegmator is greatly reduced. Control of the temperature drop across the dephlegmator insures proper operation and a minimum consumption of cooling water. Maintaining the flow of lime to the still in proportion to the liquor feed to the still assures maximum efficiency and economy of the lime treating process.

Recording and controlling pyrometers with electronic circuits using standard radio tubes eliminate the necessity of dry cells, standardizing cell and a galvanometer. These instruments are particularly suited for installation in operations and locations where decided vibration exists. Their increasing use illustrates the wide adaptability of electronic principles to chemical and process industries.

Among the trends to be noted in instrumentation is that to the use of radiation pyrometers for temperature measurements under many unusual conditions. For example, Leeds & Northrup Co. reports that the temperature of open-hearth and other furnace blooms can be detected as can the temperature of moving narrow objects of constant width and position, such as wire, rod, or streams of molten glass or slag. The instruments can be chosen to indicate, to record, to signal, to control, or to perform these functions in any combination. They have been used in cement plants, sighted directly on the clinkers, to note temperatures at any moment.

An interesting application of a differential-pressure controller to maintain a constant outlet temperature from a 30-plate column still has been designed by The Bristol Co. as shown in an accompanying illustration. Such differential-pressure control of still temperatures can find numerous applications in chemical industries as well as in petroleum refineries.

A resistance vacuum gage of the modified Pirani type has been developed by General Electric to fill a need created by the recent trend toward lower vacua in processing. If a heated wire is placed in a vacuum, the degree of cooling of the wire is determined by the magnitude of the vacuum. This phenomenon is utilized by the resistance gage to measure very low pressures. The indicating milliammeter is calibrated to read directly in microns with scale ranges from 0-20 microns and 0-100 microns. In general, experience has shown that the minimum pressure which can be read is in the order of 0.1 micron.

QUANTITY OR FLOW RATES

Recently there has developed a decided trend in the process field toward increased size of equipment, thus making it become necessary to use more powerful actuating mechanisms than has been the custom in the past. Hydraulic control mechanisms for this purpose have been developed and used in the boiler plant and steel mill, and to some extent in process fields such as the T.V.A. phosphate plant and in the synthetic ammonia plant of the Atmospheric Nitrogen Co. One illustration of this recent trend is in the use of hydraulic controllers for operating Chapman slide valves in fluid catalyst petroleum plants for producing aviation gasoline.

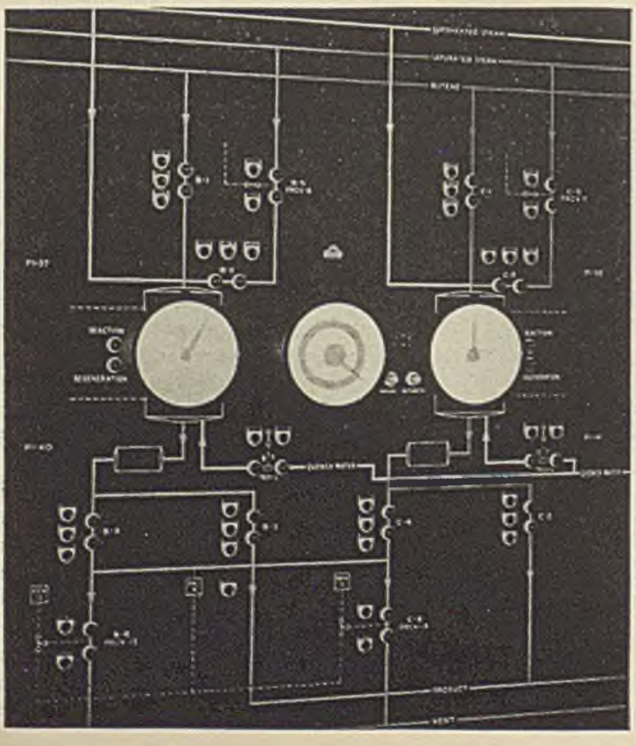
Valve positioners are auxiliary control devices which position a diaphragm-valve disk precisely in proportion to the air pressure changes from the controller regardless of valve-stem friction, diaphragm-motor hysteresis or size of the process time lag. They have been recommended for all chemical or other processes which have time lags or heat capacities which require the controller to be adjusted for low or medium sensitivity.

Electronic control may be applied to a pressure-reducing valve so that it retains its primary function but, in addition, becomes a volume valve as well. Fluctuations in supply pressures are compensated for by valve movements as they occur and the delivery pressure is maintained without variation. Similarly, when an increased volume of steam is required, the demands are met as they occur and steam is supplied at a pre-selected value. Hurley Electronic Controls can put out many makes and types of reducing valves that are controlled electronically in this manner.

In general, electric motors driving a single, adjustable lever system through built-in gear reduction may be used for valve operation. Either slip-stem valves or one or more rotary-stem valves may be so controlled. They may be obtained in splash-proof, acid-proof or explosion-proof construction as required, and they find numerous applications in the chemical industry for controlling the flow of air, gas, steam, oil or chemical solutions.

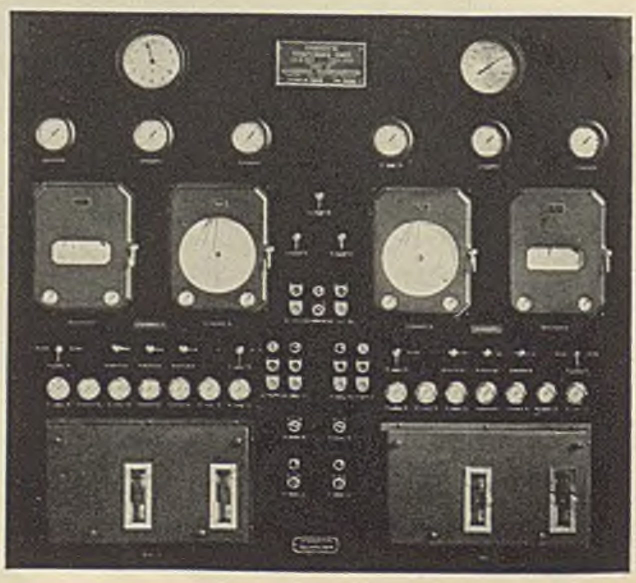
Aneroid manometers, such as those put out by the Taylor Instrument Companies, are designed to overcome the disadvantages of the present mercury shortage and to simplify the more complex problems of flow and liquid-level control. They are suited for use in processes involved in the manufacture of butadiene, styrene, high-octane gasoline, alcohol, acids and other chemicals.

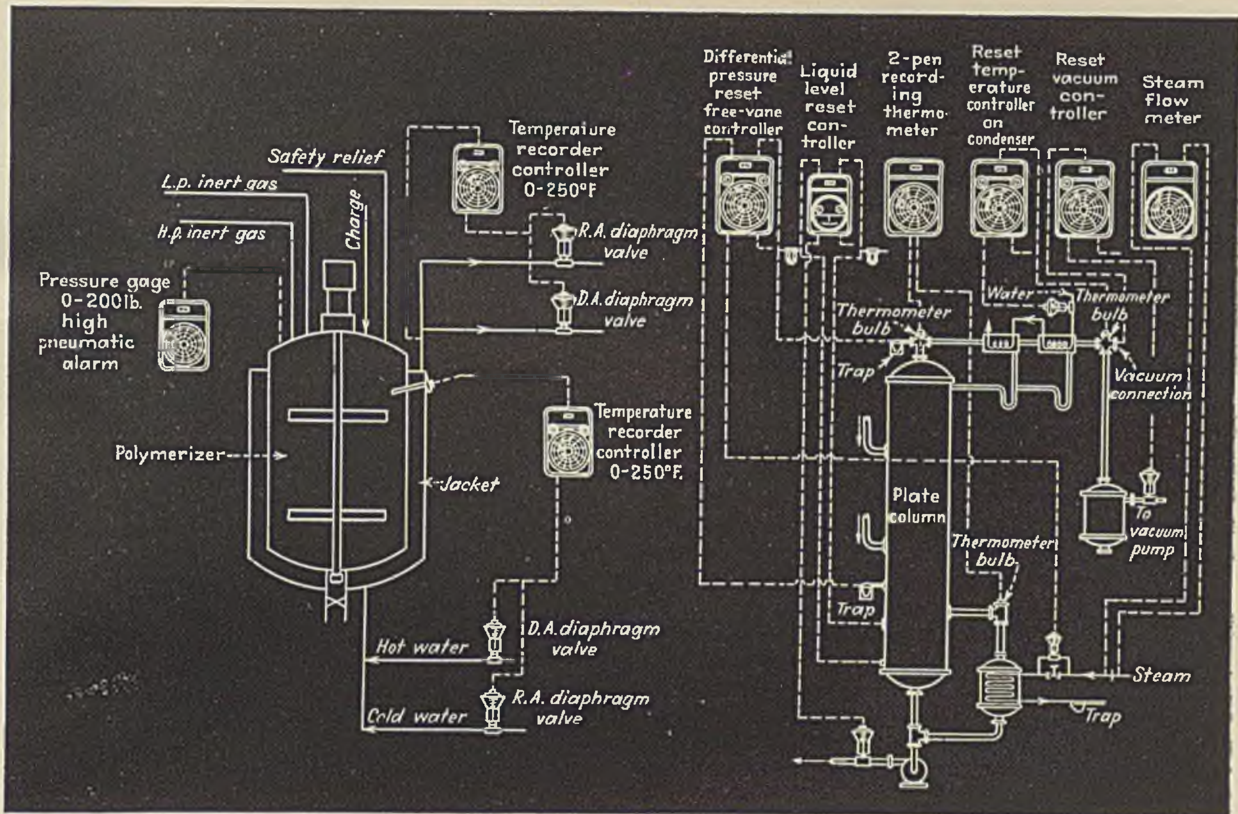
Cochrane engineers report that the electrical controls put out by this concern have been finding increasing use in determining flow rates for adjusting duration of backwash, brining and rinsing operations in carbonaceous zeolite water softeners, for public utilities and other purposes. The flowmeter can also actuate a phosphate proportioning feeder and sulphuric acid proportioner. The totalizing integrator of the electric flowmeter measures water treated between regenerations of the zeolites. Signal lights indicate which units are in operation. Such instruments are also used for deaerating hot process softeners with a phosphate treatment. The flowmeter



Left—Complete timing system for synthetic rubber process plant controls sequence and duration of actuation of more than 60 valves. Built by Automatic Temperature Control Co.

Below — An example of Taylor coordinated control panel regulating temperature and pressure in proper sequence and duration





This special controller by The Bristol Co. incorporates all the equipment needed for automatic temperature control in the complete polymerization process for butadiene and copolymers

Set-up of an interesting application of a differential-pressure controller to maintain a constant outlet temperature from a 30-plate column type still, designed by engineers of The Bristol Co.

actuates two chemical feeders, one for phosphate and one for coagulant.

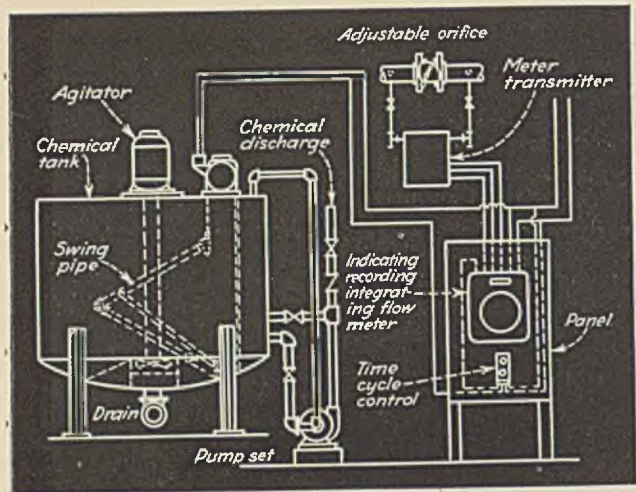
Flow of opaque or viscous fluids, and fluids that are corrosive to glass such as hydrofluoric acid and concentrated caustic soda solutions may be measured and controlled by means of the Magna-Bond remote recorder controller of Fischer & Porter Co. Because of its magnetic transmission it can also be made completely without electrical connections so that it finds application in oil refineries and distilleries where flammable liquids and gases preclude the use of electrical meters.

The remotely controlled Rotaweir was developed by Fischer & Porter Co. so that a proportioning weir could be set high on a distilling column and yet be controlled from the main operating floor. This product, in both hand-operated and electrically-controlled form is being used by many byproduct coke plants for proportioning reflux to products.

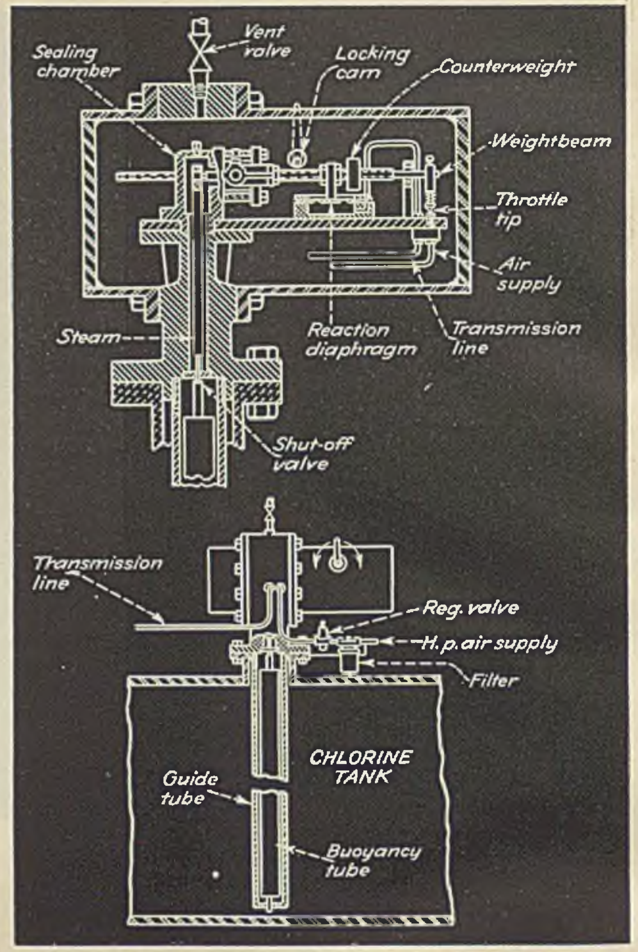
In electrochemical operations, an important saving in power cost can be accomplished by the use of mercury arc rectifiers, which operate most efficiently at a temperature of about 135 deg. F. Hence, maintenance of cooling water temperature prevents loss of efficiency in the form of dissipated heat. In general, there are three systems of control for these units. One is a water-to-water heat exchanger, with proportioning type control valves to maintain the proper flow of water used for the heat exchanger. Another operates by means of an air-to-water exchanger in which a duplex valve is used. System three is a combination cooling arrangement making use of air-to-water and water-to-water heat exchangers. The majority of rectifiers installed to date in electrochemical operations, such as manufacture of metallic aluminum and magnesium, make use of the water-to-water control arrangement. Use of this system is naturally increasing, report Barber-Colman engineers.

Bellows-operated type recorders are being used for measurement of flow, differential pressure and liquid level. They are particularly well suited under high static and high differential pressures, in mobile services, and where mercury is objectionable or prohibited. Such recorders are used in process industries for measurement of certain chemically active fluids, such as liquid ammonia and oxygen at pressures of less than 100 lb. per sq.in., and for measurement of various viscous fluids.

In the weigh-tube type liquid-level transmitter the dry weight of the tube is balanced by springs, the larger being stiffer than is necessary, with the smaller spring acting as a vernier. The device can be used to measure liquid-to-liquid interface, and a special variation of the instrument has been designed for liquid density measurement. This transmitter is well suited for very high operating pressures or for the measurement of level of very corrosive liquids, such as are often encountered in chemical industries. The buoyancy type liquid-level transmitter can be used to measure liquid-to-liquid interface and density of liquids. The Republic Flowmeters Co. furnishes this type of transmitter for working pressures up to 600 lb. per sq. in. and temperatures to 400 deg. F., with tube lengths up to 50 ft. A special construction of this buoyancy type instrument has been developed for liquid chlorine level transmission, as shown in an accompanying illustration. For safety reasons, no connections may be made to chlorine storage tanks below the liquid level, and it was therefore desired to indicate the level by means of an instrument which could be inserted through a flange at the top of the tank. The instrument case must be strong to withstand 300 lb. per sq. in. pressure in case of failure of any of the working parts. The chlorine



Arrangement of chemical feeding equipment utilizing the electrically-operated swing-pipe proportioner (Cochrane Corp.)



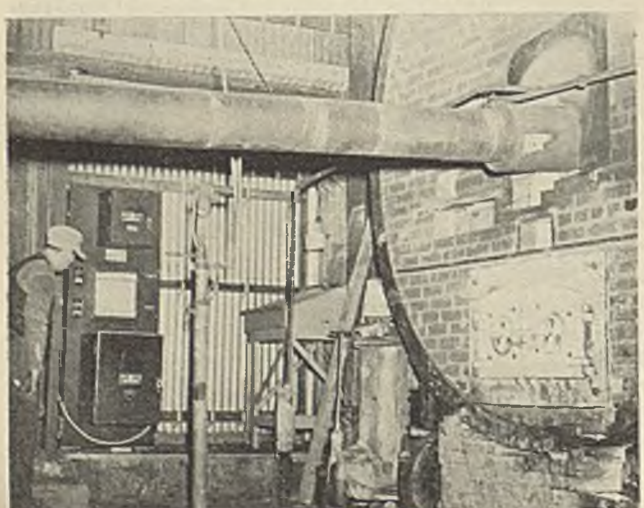
Republic Flow Meters Co. special construction of the buoyancy type liquid level transmitter for use with chlorine storage tanks

is refrigerated so that the ordinary storage pressure is no higher than atmospheric.

Consisting of an electronic tube, a transformer, a relay, and associated parts, remote controllers such as put out by Wheelco Instruments Co. can be utilized in many process applications involving rate of flow. They can be actuated by any means which will affect the capacity or inductance of a pick-up unit. In no case is it necessary to have any contact between the factor being controlled and the actual control apparatus. Applications include automatic weighing where a vane on a scale is made to enter an opening in an inductive pick-up unit, boiler level control, or liquid-level control where a capacitive pick-up unit is attached to a gage glass, and flow or differential pressure control where a capacitive pick-up unit is applied to a differential pressure manometer.

Electronic tubes and circuits are finding ever-increasing applications in chemical and process industries for weighing operations. Prominent weighing scale manufacturers, such as Toledo Scale Co., use standard photoelectric relay equipment with contactor circuits of their own design for precise weighing. Material flows rapidly onto the scale hopper until the indicator pointer intercepts the light beam. This causes the photoelectric relay to operate, reducing flow to a trickle. Finally the slow movement of the pointer again permits the light to strike the phototube and the flow is stopped completely at the proper weight required.

General Electric photoelectric pyrometer panel with double chart recorder, amplifying equipment and speed-control contactors for temperature control of rotary cement kilns



Automatic weighing equipment such as that put out by Builders - Providence, Inc. is used for accurate weighing of materials transported on a belt conveyor, the gravimetric control of flow of solids on a conveyor, and proportioning of other materials to the flow. Although essentially weighing devices, automatic weighing equipment has been designed to function in a much broader capacity for controlling operations in the chemical process industries. In one such application designed by Merrick Scale Manufacturing Co., the load indicator is used to control the addition of a second substance in proper proportion. As the product travels along a belt conveyor it is weighed and the scale automatically selects the proper number of atomizers through which the second liquid material is sprayed.

Republic Flowmeters Co. has reported a differential transmitter in which the action of the weigh beam is reversed to permit the low pressure to be connected to the bottom, the high pressure to the top of the differential diaphragm. This was done to permit making the minimum number of parts of corrosion-resistant material. The application is to measure the differential pressure between two vessels in one of which is a very corrosive poisonous gas, and in the other an inert gas to be maintained at a pressure slightly higher than that of the corrosive gas, regardless of the actual value of this latter pressure. In other words, in this case the inert gas acts as a sealing fluid for the corrosive one. This represents a new design and is a reversed weigh beam pneumatic differential transmitter that can undoubtedly find numerous applications in chemical and process industries handling such gases.

A sensitive ballast type instrument for use in self-balancing bridge circuits is the polarized Micro-Relay of Barber-Colman Co. This is used, as shown in an accompanying illustration, in conjunction with various instruments to control temperature, pressure, liquid level, speed, pH, and moisture regain for industrial process work.

COMPOSITION CONTROL

Instruments and controllers may be applied to a chemical tank to measure and indicate, record and control characteristics of the chemical. The control is for the purpose of regulating the level of the liquid in the tank, the indicator is to show the level of the liquid in the tank at a remote point, and the recorder is to record the specific gravity of the liquid. With the instrument put out by the Hays Corp., all equipment used is of a dry diaphragm type. The controller is connected to a motor-operated valve in the fluid line. The recorder is sensitive enough to register accurately increments of 0.0025 in. water pressure and can be calibrated to give specific gravity.

Solids in suspension and gases in solution as well as salts in solution make this type of measurement and control of specific gravity and level a problem which can be well handled by the dry diaphragm type of gage. The same type is being used to indicate pressure in the reactor rooms of synthetic rubber plants, where it is desirable to maintain a slight positive pressure.

The pronounced trend toward the use of electronic devices is emphasized by the electric smoke indicator manufactured by Brooke Engineering Co. By the use of electronic tubes, which directly supply the current to light-indicating lamps, all electromagnetic relays are eliminated. Indicating lights will indicate minute changes in smoke density. This same system can be used to control natural draft oil-fired burners.

Municipal and industrial water filter plants and industries using process water are improving corrective treatments by the use of instruments for automatic indicating and recording, or for indicating, recording and controlling pH. Also, in the sugar industry, cane mills are improving clarification of juice by the use of automatic control to maintain pH at the value for best clarification. Similarly, in an increasing number of beet sugar mills, juice is being limed or gassed to a specified acidity by means of automatic equipment which measures the pH of a continuous sample and regulates lime or gas-flow accordingly.

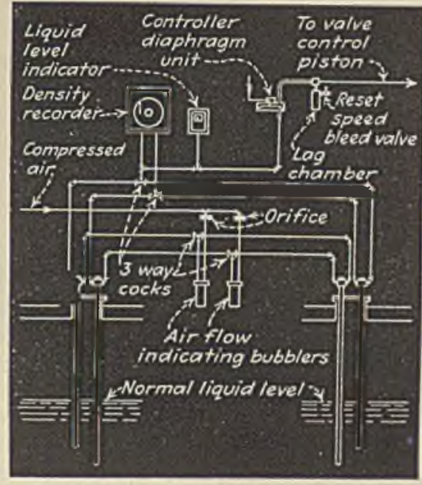
In the paper industry, use of pH recording and control instruments such as those put out by Leeds & Northrup Co. has resulted in greater uniformity of characteristics such as paper strength, texture and color.

A most important recent development in pH equipment is its application to synthetic rubber production. To handle this job, National Technical Laboratories has developed a new type of non-coagulating electrode, since with conventional electrodes the rubber latex tends to coagulate at the calomel electrode liquid junction. At the present time, the pH installation consists of automatic recording and controls in the coagulating step, and in continuous indication in the preparation of the soap solution used in the process.

Other pH applications of interest to the industrial war effort are found in electroplating, flotation, magnesium production, purification of bauxite, in addition to the numerous ordinary applications in chemical processing. In electroplating, control of chromic acid baths for anodizing aluminum is a major new development. The new Beckman electrode which has negligible sodium correction in highly alkaline solutions, has led to greatly improved pH control in alkaline plating baths, particularly various cyanide solutions.

In flotation, pH control is making possible the recovery of considerable tungsten from tailings from old workings. In magnesium production, automatic pH control is being used in the neutralization of magnesium hydroxide slurry with hydrochloric acid. In one plant alone, this equipment is doing automatically work which otherwise would require the services of 130 analytical chemists. An analogous application is the purification of aluminum oxide. Among the many other important applications of pH control is in the recovery of pyridine.

Dewpoint potentiometers for determining the moisture content of gases have been finding increasing applications in various industries, particularly metallurgical and heat-treating processes. They are also used in the manufacture of compressed gases, such as oxygen, hydrogen or nitrogen to measure the humidity of the gases at various stages, such as at the outlet of compressors, storage systems, etc. They have found use in checking furnace atmospheres for moisture content in order to guard against decarbonizing



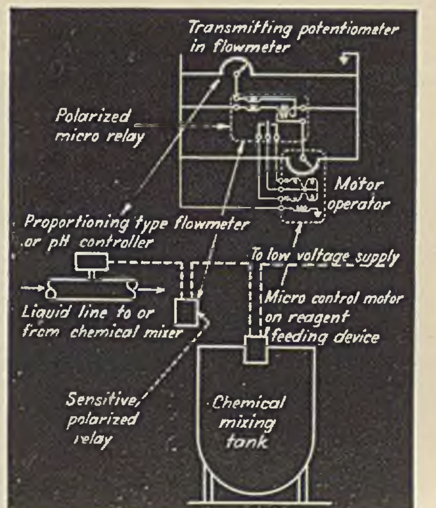
Diagrammatic layout of liquid level control and density recording built by the Hays Corp. for pulp level control

in processing and annealing of high-carbon steels, in testing laboratories for checking materials and plant processes, and in testing city gas, partially burned gases and flue gases.

Barber-Colman Co. has developed an improved type of moisture content controller which regulates the speed control motor to maintain any desired moisture content of travelling material. Moisture content in terms of percent regain can be measured and recorded on fabric materials such as cotton, rayon, wool and paper within a fraction of one percent. The instrument normally controls the speed of the dryer.

Applications of oxygen recorders can be found in industries with furnace atmospheres or other places where it is required to maintain a definite amount of oxygen for process control, safety precautions, or to enable efficient operations of different kinds of

Showing the use of Barber-Colman polarized Micro-Relay operated from a transmitting potentiometer located in a proportioning type flow meter



inert gas producers. High-pressure power stations, for instance, require records of dissolved oxygen in the feed-water in order to measure and control certain factors that influence corrosion. Again, in order to insure efficient combustion conditions in cement kilns, it is becoming a general practice to test the flue gases for oxygen content. One type of instrument put out by Cambridge Instrument Co. has been in successful use for this purpose for a number of years.

Considerable interest is being focussed on the new infra-red spectrophotometer put out by National Technical Laboratories. This instrument, available for record analysis of hydrocarbon gases, is now being delivered to refineries producing aviation gasoline and butadiene. With the instrument, it is possible to perform a complete analysis of hydrocarbon gases, including all of the C_3 and C_4 fractions. Such an analysis would take about 24 hours by the conventional low-temperature distillation process, but with this instrument the time required is about 40 minutes and the accuracy is even greater than that of the older method. The infra-red instrument is also being used to follow polymerization reactions of many types, including those occurring in the manufacture of plastics and synthetic rubber.

Quartz photoelectric spectrophotometers have been put to a number of uses. First major use was the determination of vitamin A by use of the spectral absorption at 328 mmu. Another important use in the war program is the determination of toluene. A complete and accurate analysis for toluene can be made in 15 minutes with the instrument put out by National Technical Laboratories, in contrast to the many hours required by older methods.

The Westinghouse Electric & Manufacturing Co. mass spectrometer can be applied in industrial research, refinery and chemical plant laboratories and perhaps in operational control. Its primary value at present is for the analysis of gases, with the present limits of accuracy at about one percent. The instrument might be used to determine continuously the percent by volume of one constituent of a mixture of hydrocarbon gases provided the mixture contains a limited number of components.

Leeds & Northrup electro-chemographs consist of a dropping mercury electrode used in connection with amplifying and recording equipment. Satisfactory results of its use have been reported for industrial analyses of water, explosive, gas and metallurgical and mineral products.

CYCLE CONTROL

Time controls are installed in chemical plants to (1) guarantee maximum output, (2) provide operation through the indication of signals and alarms, (3) cut down on skilled man-hours, (4) insure product uniformity by repeating the ideal sequence of operation, either consecutive or overlapping. The timing mechanism may be used to provide automatic lubrication of chemical processing machinery, actuate agitator motors, trip chemical tank traps, etc. The automatic feature eliminates human errors in time setting. R. W. Cramer Co. reset timers are used, for instance, for heat-treating operations which must be maintained on uniform time cycles. Another use is for the supervision of a bank of infra-red lamps or other heating loads.

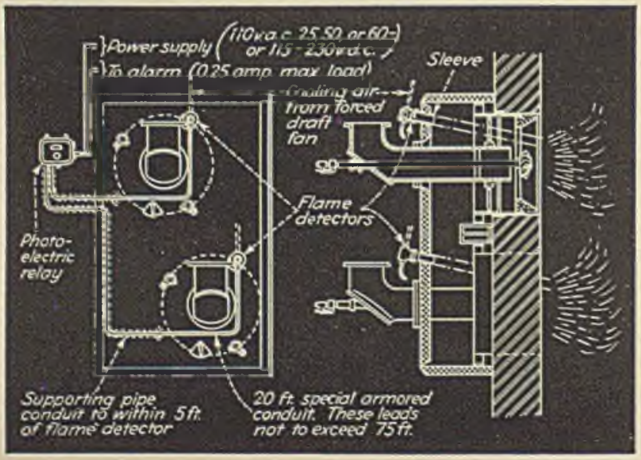
Complete time-control panels can be built to users' specifications for special applications in synthetic rubber, petroleum cracking, and other catalytic processes requiring the opening and closing of a large number of motor- or soleniod-operated valves at definite but adjustable times, in a definite but rearrangeable sequence. One such time-control system put out by Automatic Temperature Control Co., is completely interwired and supplied with indicator lights and switching stations and can control the sequence and duration of the actuation of more than 60 flow valves. Another special installation in a Houdry petroleum cracking plant controls 900 circuits.

For similar applications, General Electric Co. recently developed a time-cycle and valve-operator control which includes the control for valve operators, a motor-driven cycle timer, interlocking and alarm relays, valve position indicating lights, and auxiliary timers to shut down the main timer during periods when valve operation is not required. These cycle timers are made available with from 100 to 900 points or segments energized by means of a traveling arm and auxiliary contact.

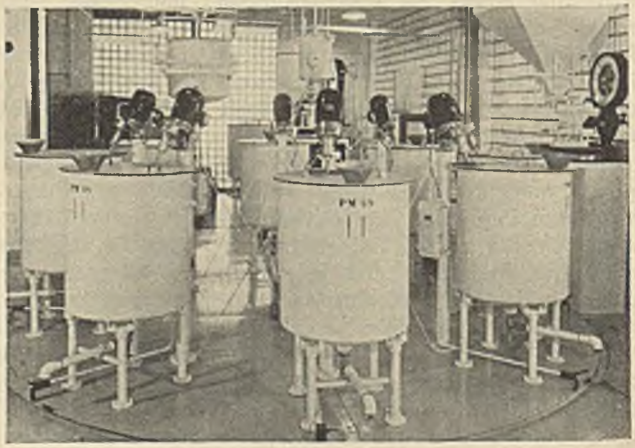
Some ten or twelve cycle timer controls were built and installed during 1942 in petroleum refineries and butadiene plants, and at least one found its way into a conventional chemical process. The advent of the continuous fluid catalyst and the moving-bed catalyst in refinery plants may make unnecessary such valve operation; but these devices are now being applied to the new synthetic rubber industry and increasingly to the chemical industry. In the plastics industry, time-cycle controllers have been applied in the control of molding operations and on laminating presses.

Reprints of this 48-page report are available at 50 cents per copy. Address the Editorial Department. *Chem. & Met.*, 330 W. 42nd St., New York, N. Y.

Typical application of Bailey Meter Co. flame detectors to a boiler fired with pulverized coal and oil, using preheated air



Turntable in a Campana mix room, with indexing limit switch for spotting tanks and General Electric photoelectric scale



Three Plants In One

JAMES A. LEE *Managing Editor, Chemical & Metallurgical Engineering*

Chem. & Met. INTERPRETATION

This plant is of particular interest to chemical engineers. It is the first aluminum plant in which low grade domestic ore was used exclusively. This is the first commercial plant to use closed circuit wet grinding of bauxite. The "bedding down" of bauxite was introduced. Most of the red mud is removed by settling rather than by filtration. Rectangular Soderberg continuous electrodes are used in the cells. Rolling doors are provided for the furnaces.— *Editors*

The plant was designed to permit use of both imported and domestic bauxite. Although it has been in operation only two years a wide range of grades has been processed

In 1940, R. S Reynolds, as an aluminum fabricator, became interested in the future availability of the metal to meet wartime needs. As the result of his investigation he foresaw a shortage but found he could do very little about it. It was suggested to him that he, himself, might go into the production of virgin aluminum thus solving the problem. His affirmative decision consummated the second marriage between the process of making aluminum and capital in the history of the United States, and the first event of this kind in half a century.

This decision was quickly put into definite form with the construction of the first aluminum plant in the Western Hemisphere and probably in the entire world to start with the bauxite ore, process it to alumina, reduce the oxide to metal, and roll sheets, rods and bars, all in one continuous straight-line flow of materials over a mile in length. Throughout this long line are numerous evidences of pioneering spirit. (1) It is the first aluminum plant in which low grade domestic ore was used exclusively; (2) This is the first commercial plant to use closed circuit wet grinding of bauxite; (3) The bedding down of bauxite was introduced; (4) Most of the red mud is removed by settling rather than by filtration; (5) Rectangular Soderberg continuous electrodes are used in the cells, and (6) Rolling doors are provided for the furnaces.

When the decision was made for the Reynolds Metals Co. to produce virgin aluminum it was necessary of course to select the most advantageous location for the plant. Reduction of alumina to the metal requires a tremendous amount of power and so the survey narrowed quite rapidly to areas in which large blocks of power could be quickly obtained. This soon resulted in a choice between the government's northwestern power supply and the Tennessee Valley Authority. After due consideration a site adjacent to Wilson Dam on the Tennessee River at Muscle Shoals, Ala., was chosen. This plant site was named Listerhill in honor of U. S. Senator Lister Hill, who had made the suggestion to Mr. Reynolds that he go into the aluminum industry.

This location afforded water and rail transportation for imported bauxite brought into the ports of Mobile and New Orleans, and domestic ore from Arkansas and Alabama, and for such other raw materials as petroleum coke, soda ash, caustic soda, and lime. Muscle Shoals is not far from the then largest fabrication plant of the Reynolds Metals Co., at Louisville, Ky. Not only did the Tennessee River offer power, but in addition a navigable stream for something like 600 miles of its length.

The climate in northern Alabama is mild, the winter is practically open. The local labor was both plentiful and intelligent. This applies to both white and colored employees.

Work was started on the design of the alumina and reduction plants in the office of the engineers, J. E. Sirrine & Co. on Sept. 1, 1940. Three months later the plants were designed and most of the equipment purchased. Construction commenced November 20. With the fall of France and the accompanying increased demand for aluminum every effort was made to complete the plant as quickly as possible with the result that in two days less than six months after start of construction metal was produced, May 18, 1941.

In January, the design of a rolling mill got under way and the hot mill of this unit first turned in July. The mill as a whole began to function at an increasing rate during the later months of the year.

The alumina plant was designed to permit the use of both imported and domestic bauxite. Although it has been in operation only two years a wide range of grades has been successfully processed. On one end of the scale has been high grade bauxite with 4 percent silica and 60 percent alumina, and on the other low grade ore with as much as 14 percent silica and only 40 percent alumina.

Ore is handled and stored by an

elaborate system of conveyors. Like all other raw materials, bauxite is received at the plant by railroad. It arrives in gondola cars from which it is dumped through grizzlies into a track hopper. From here the ore is transferred by a 48-in. pan feeder with variable speed control and a 36-in. belt conveyor onto a vibrating screen. Oversize material is crushed in a Dixie hammermill and rejoins the ore from which it was separated on a 36-in. belt conveyor which delivers to the head tower of a drag-line installation.

Each grade of ore is piled separately in the great semi-circular storage area. The ore is recovered by the drag line as required for blending in the bedding down building. It is carried from the storage area by a 24-in. belt to the top of the bedding building in which it is distributed in horizontal layers by means of a reversible tripper conveyor. At the entrance to the building a continuous sample of the ore is taken. The structure is divided into two parallel bins providing undercover storage for four-days plant requirements.

Ore is withdrawn from the bedding building at the angle of repose and falls to another series of 24-in. belt conveyors at the bottom, which delivers it to a small bin in the grinding building. The bauxite feeds by gravity onto a Feedoweight which controls the input to the system. It discharges into the feed neck of a 6x10 ft. Allis Chalmers ball mill working in closed circuit with a Dorr classifier.

Wet grinding of the ore is used in this plant for several reasons; (1) It simplifies the operations; and (2) It is a cleaner operation and avoids the handling of wet clay which is troublesome. Grinding is done with return caustic liquor from the evaporators in a closed circuit with a single deck 4x20 ft. duplex classifier. Oversize material is returned to the mill for further grinding.

Burned lime in a maximum size of ¾ in. is also received in cars. It is discharged from the cars into a screw conveyor, followed by an elevator taking it to two 75-ton conical bottom, cylindrical steel bins. From these bins lime is fed by a screw conveyor to a small hopper feeding a Feedoweight conveyor. It discharges into a screw conveyor carrying material to the ball mill feed chute.

Soda ash is brought to the plant in cars and is stored in a concrete silo and a conical bottom steel bin. The concrete silo is the prefabricated type, composed of concrete staves held together by steel hoops. Ash is fed to the steel bin by means of a variable speed screw feeder and screw conveyor to join the line discharging from the Feedoweight conveyor. Of the dry chemicals, bauxite and lime critically affect the ratio of alumina to free caustic soda which determines the degree of precipitation and particle size of the finished alumina. The addition of soda ash is controlled in order to maintain within approximate limits the concentration of sodium ions in plant liquor.

Under wartime conditions the location of this plant with reference to ordnance plants makes it economical to substitute 50 percent caustic for lime and soda ash, consequently, caustic is generally used. It is received in tank cars and stored in two 30 ft. x 40 ft. steel storage tanks. As required, it is pumped and metered from these tanks to join the evaporator discharge where it enters the circulating storage tanks.

Mother liquor, from which aluminum hydrate has been precipitated and settled, is pumped through two quadruple-effect evaporators in parallel. The evaporators serve to remove excess process water. In order to maintain liquor concentrations at the desired level and to prevent excessive swelling of process stock, concentrated liquor is pumped to the first of three storage tanks in series. Circulation is maintained across this group of tanks so as to prevent channeling with resultant fluctuations in liquor analysis.

The liquor is pumped from these tanks through a flow recorder-controller which sets the plant liquor flow. On the downstream side of this control valve the liquor is split. The major portion of it goes directly to the digester feed tank. The balance serves as dilution in the ball mill and classifier. The liquor overflowing the classifier, with all minus 20 solids, is pumped to the digester feed tank as previously mentioned.

The pulp containing bauxite and added soda ash and lime is pumped to two 8 ft. diameter x 72 ft. long horizontal continuous digesters, each equipped with revolving stirrer mechanism to retain the solids in suspension. The digester inlet is on the upper side of the cylindrical shell and the discharge is on the lower side, which makes the agitation easier, and tends to shorten the retention of the coarser particles in the red mud. Digesters are connected in series to increase the retention. Live steam is introduced into the first of these digesters to effect an operating temperature of 290 deg. F. The 125 lb. steam pressure is supplied by four connections of 3 in. diameter at the inlet end. A third digester is used as a standby.

Digester detention provides approximately three-quarters of an hour for extraction of alumina and desilication of resultant liquor. Almost 80 parts by weight of alumina are put into solution per 100 parts of sodium hydroxide, which is the maximum amount of alumina that will be held in solution at the boiling point of the solution at atmospheric pressure after it leaves the digester.

Pulp after digestion is released continuously from the second of the two digesters by means of a 4 in. Merco Nordstrom valve under its own pressure into the first of three flash tanks that are arranged in series. The vapor pipes from these flash tanks are connected to different stages of the quadruple-effect evaporators. The flash tanks are about 7 ft. in diameter by 12 ft. high.

In the flash operation superheat of the pulp is dissipated so that mixture of aluminate liquor and red mud can

Ore is handled and stored by an elaborate system of conveyors. It is screened and the oversize crushed in building on the right. Bedding building is at left

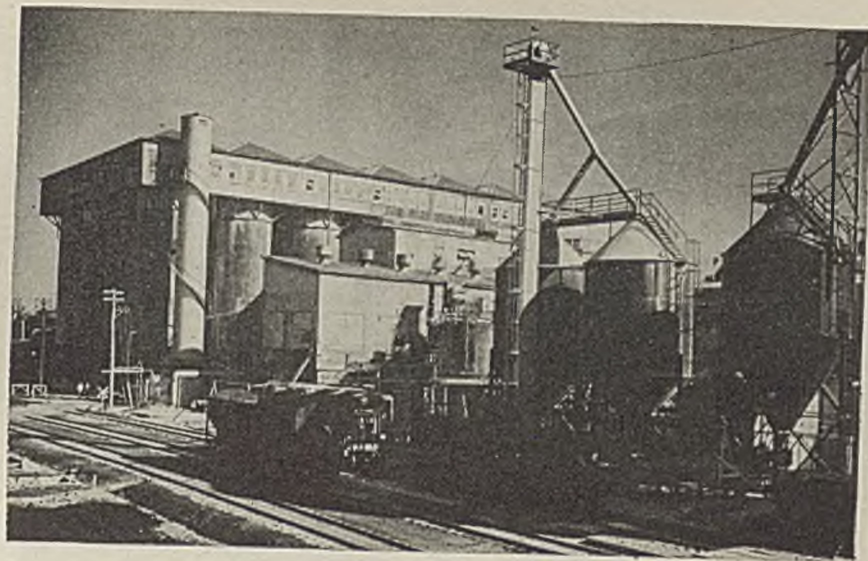
be introduced to the settling equipment at atmospheric pressure. This dilute pulp mixture is introduced into three primary thickeners from which relatively clear aluminate liquor continuously overflows. The settled solids are re-introduced into three washing thickeners of five-compartments each. These tanks furnish countercurrent washing of the red mud solids and recovery of the settled liquor.

The final underflow of these washers is pumped to a battery of four Oliver vacuum filters. On these units hot water sprays remove the remaining aluminate liquor from the red mud before it is discharged as a damp cake to the disposal pond.

This filtering and settling equipment, which was designed for high grade bauxite and on which it operated quite satisfactorily, gave considerable operating difficulties with low grade ore. A very tenacious foam formed on the thickening tanks, resulting in a considerable carry over of fine solids which loaded up the Vallez filters very quickly. All sources of air admixture with the slurry had to be eliminated to get a reasonable capacity. Pipe lines that had been in service for nearly a year on high grade ore without any sign of wear were cut through in two weeks time when the change was made to low grade ore. The increased amount of heavy sharp sand continued to wear out these lines quickly until the trouble was overcome by changes in design. Now the bulk of the objectionable material is trapped in conical bottom tanks before the red mud is introduced into the primary thickeners.

The combined liquor overflow and wash liquors from the thickeners and washers is piped to a 14 x 14 ft. central storage tank. From this storage the unclarified hot storage liquor is pumped to a battery of eight Vallez closed cycle clarification filters, each with filtering surface of 95 sq. ft. The 35 filtering units of each of these rotating leaf pressure filters are covered with Monel metal or stainless steel screens upon which a precoat of paper pulp is introduced by circulating pumps. A filter often operates 20 to 24 hr. before it is necessary to shut down for cake removal.

Filter feeds may approximate 250 parts per million of suspended solids. Clarified effluent from the filters has been reduced to 10 to 20 parts per million. The clarifier liquor at this stage still retains a temperature of 200 to 210 deg. F. Before introduction into precipitation units the temperature is lowered by passage through a battery of six heat exchangers. By countercurrent flow the heat exchangers raise the temperature of spent liquor feeding the two evaporators.



Precipitators appear at left. Lime is discharged from railroad cars into screw conveyor and elevated to two 75-ton conical bottom, cylindrical steel bins on right

Cooled and clarified strong aluminate liquor is treated in a battery of twenty-eight 20 ft. diameter x 60 ft. high straight side precipitation tanks. These conical bottom tanks are supported at the lower end by steel columns welded to the tank side and carry a light housing at the top, the floor of which serves as operating platform. Each tank is provided with a simple air lift pipe 10 to 12 in. in diameter with an air pipe of about ¾ in. providing circulation. The practice is to fill a tank with aluminate liquor up to within 8 or 10 ft. of the top and then to add about 6 ft. of fine aluminum hydrate from the seed tank. The contents of the precipitation tank are then agitated with the compressed air for a period of from 24 to 36 hr., during which time the alumina is precipitated to a minimum value in the solution.

Each precipitator charge is successively emptied through a surge tank and a pair of Dorr hydroseparators. These hydroseparators perform a rough classification. The fines which overflow the hydroseparators are collected in four-compartment thickeners. Clear overflow of these thickeners is the spent liquor which returns to the grinding circuit via the heat exchangers and evaporators. Settled solids from these thickeners in the form of a pulp containing 45 percent solids is the seed used for subsequent precipitation.

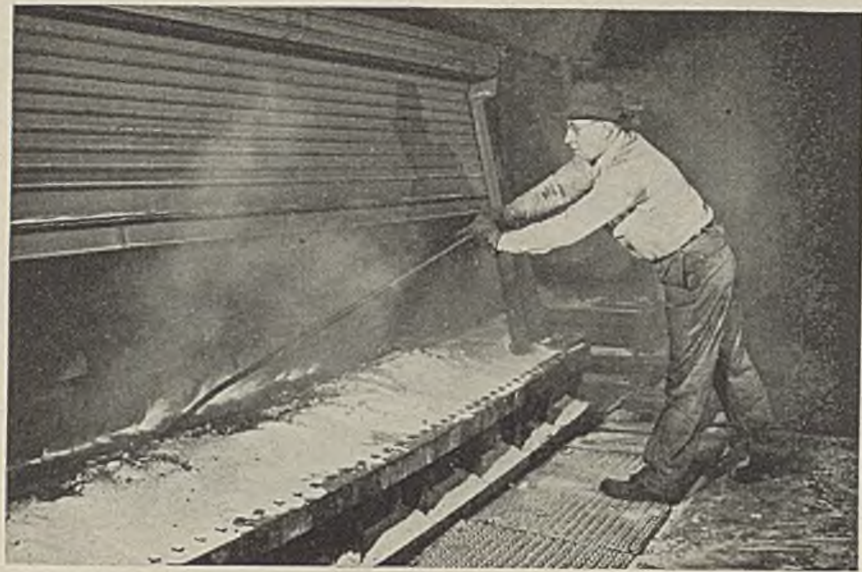
The coarser part of the precipitated aluminum hydrate settles and the underflow goes to two 8 ft. three-deck classifiers where a part of the associated alkaline liquor is washed out. In these units still weaker liquor from the dewatering filters are used countercurrently in washing the rake products. The combined overflow containing some fine solids is returned to the two hydrate thickeners.

From the Dorr classifiers the raked, partly washed hydrate is pumped to two storage and surge tanks. These in turn feed a battery of four Conkey rotary hopper vacuum dewaterers. In these filters vacuum and fresh hot water wash remove the last of the soluble alkali from the finished hydrate. Each dewaterer precedes a calcination unit consisting of a screw conveyor feeder, kiln and cooler. Washed cake containing 10 to 12 percent moisture is fed by a 16 in. horizontal screw conveyor into a rotary kiln.

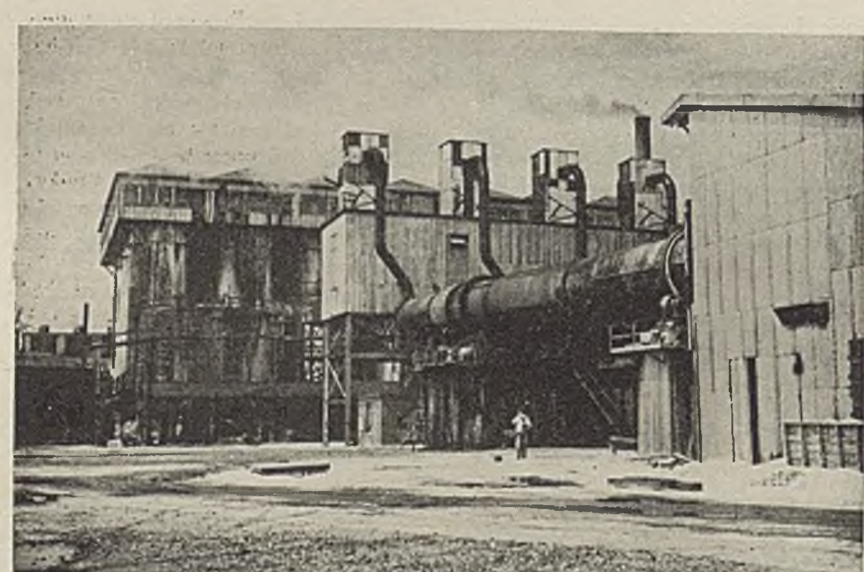
There are four kilns with a diameter of 8 ft. at the feed end, and a length of 135 ft. They are oil-fired, steam being used for atomizing the oil. Each kiln has a capacity of 90 tons a day. The feed-in temperature is between 500 and 600 deg. F. On the firing end of the kiln the temperature approaches 2,000 deg. F. The waste gases from the kilns are drawn into a draft fan which discharges them to the atmosphere through two sets of four multiclone dust recovery units.

The kilns are provided with special Allis Chalmers multitube rotary coolers 9 ft. in diameter and 20 ft. in length, in which the combustion air is passed around a number of steel tubes, calcined alumina passing inside the tubes. Cooling air is introduced into each cooler by a forced draft fan delivering 3,000 cu.ft. per min. of air. A portion of the cooler air is diverted through the kiln for combustion.

The calcined alumina from all four coolers is discharged and transported in an underground rotary conveyor



Alumina is spread over the surface of the cell to preheat, later it is stirred into the bath. Notice rolling sides on furnace to retain gases



Structure at feed-end of kilns is alumina washing and dewatering building. Beyond that is visible one of the hydroseparators and several precipitators

At the left liquor from precipitation tanks flows into hydroseparators. At right are two "white mud" thickeners. Building beyond is for washing and dewatering

consisting of a pipe with an internal spiral and supported on tires and rollers like a small rotary kiln. This arrangement can be used for further cooling the alumina simply by spraying water on the rotating pipes and avoids to a large extent contamination of the alumina. The alumina passes to a centralized screening and weighing installation. The finished product is then conveyed to a series of storage silos, one of which precedes each of the electrolytic cell buildings of the reduction department of the plant.

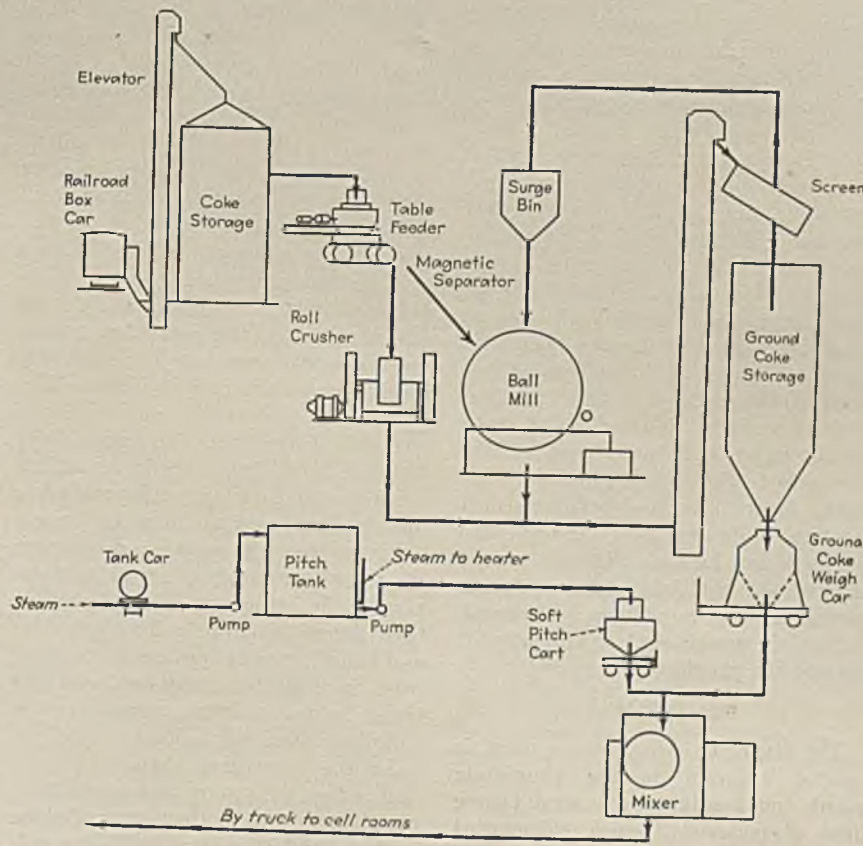
REDUCTION DEPARTMENT

There are several cell rooms, each containing electrolytic cells served by an independent bank of mercury arc rectifying units. The voltage is adjustable from practically 0 to 700 and the normal current capacity is 32,000 amperes. The cells consist of an iron shell lined on the bottom and sides with 5 in. of fire brick. There is a tamped carbon lining in which are buried iron bars for electrical contact. The carbon lining acts as cathode during electrolysis.

The carbon lining of an aluminum cell is probably one of the least appreciated mysteries of the reduction step. If the carbon is too dense or too hard a variety of electro-osmosis quickly destroys the lining. If the lining is too soft it is quickly worn and destroyed through mechanical usage and wear.

On top of the shell is placed a heavy frame from which is suspended the large rectangular continuous Soderberg electrode, which is 4 ft. wide and 10 ft. long. It is equipped with mechanism for simplifying the raising and lowering of the electrode. Rolling doors are provided on both sides of the frame of the cell so that it may be operated closed and the fumes drawn off through vents at the end and discharged out of the sides of the buildings with proper venting equipment.

The Soderberg electrode is substantially a suspended casing which is filled with a carbon paste. Production of the carbon paste is simple. Calcined petroleum coke is crushed in a roll crusher followed by a ball mill. It is then separated by screens into coarse, intermediate and fine material from which the composition is proportioned together with pitch of a melting point of about 40 deg. and mixed in a steam-jacketed vessel. The paste is conveyed while warm to the cell rooms in hopper bottom metal boxes by trucks. It is fed by cranes to hoppers above the furnaces. The paste flows by gravity through a metal cylinder to the carbon electrode in the furnace below. The carbonaceous paste as it reaches the lower end is gradually baked by the heat from the furnace as well as by the current passing through it. Iron contact pins are placed in the sides of the electrode before it is hardened and serve as electrical contacts. They are withdrawn in time to prevent solution in the molten cryolite. The electrode is gradually consumed in the furnace and consequently it is necessary to lower the electrode at regular intervals. Carbon consumption is ½ lb. per lb. of aluminum produced, or somewhat more.



Soderberg electrodes are substantially a suspended casing which is filled with a carbon paste. Here is a flowsheet for the production of the paste

The cell bath is composed of cryolite with additions of other fluorides and from 6 to 8 percent of alumina. It operates at 950 deg. C. Electrolysis proceeds quietly until the alumina content has decreased to 1½ or 2 percent. At this point the voltage protection possibilities of the alumina fail, or some other factor enters, and the cryolite bath mixture fails to wet the electrode. A gas film forms around the electrode preventing the wetting of the electrode by the bath. The voltage of the furnace rises to the point where the current is carried by small arcs through the gas film. As much as 35 to 50 volts can be accounted for by the resistance of this thin film. The concentration of power quickly heats the ends of the electrode, but of course almost instantaneously heats the gas present and greatly increases its volume. It is an old custom to connect a 50-volt light bulb near each furnace so that when this anode effect occurs the increased voltage will light the bulb and give a warning. The furnace during this period of operation, which is from 3 to 6 hr., forms a heavy crust after each working, and the next addition of alumina is spread over the crust with a shovel, both to conserve heat and to preheat the alumina. The alumina is brought into the cell room from the silo by a screw conveyor and distributed to hoppers above each furnace by crane buckets from which it is fed onto the crust of the bath through connecting pipe.

When the light warning appears, indicating an anode effect, the crust is broken, allowing the hot alumina to fall into the bath. About 150 lb. of alumina is dissolved each time the crust is broken. A rake is put through the first large opening made and pushed under the electrode. It is then given a quick jerk, which causes a wave of aluminum to rise and touch the electrode, momentarily short circuiting the furnace. This short circuit effectively kills all trace of the anode effect and as the wave of molten aluminum leaves the electrode the cryolite wets the surface again and the operation is usually normal once more. On some occasions this operation has to be repeated, but in any event contents of the furnace are stirred until the alumina is dissolved and the process of producing aluminum efficiently is resumed.

Breaking of the crust requires considerable labor but no substitute method has been devised for the difficult work involved in keeping the crust broken evenly around the electrode and maintaining the liquid bath at capacity. There are almost 5,000 lb. of material in the form of solid crust on the sides and surface, and 8,000 lb. of liquid bath.

A normal operating voltage for an aluminum cell is five volts. Power consumption does not vary a great deal whether the voltage is higher or lower than this figure.

The difference between 100 percent current efficiency and less than that efficiency is attributed to reoxidation of the metallic aluminum vapor or mist in molten cryolite above the surface of the aluminum. Normally, the gases leave the electrode quietly and bubble up in small fountains through the loose dry alumina on top of the furnace crust, adjacent to the electrode. Generally, the volume of CO and CO_2 are about equal during normal operations. However, during anode effect the amount of the former increases perceptibly. The CO_2 present presumably, is the principal cause of the reoxidation of the metallic mist. The anode-cathode distance may be from 2 to 3 in., depending upon design of the furnace and the system under which the plant is operated.

The contents of the cell being molten and, therefore, mobile, give rise at times to Hering pinch effects and corner and motor effects. Means were attempted in designing the Listerhill reduction plant to nullify uncontrollable magnetic fields as much as possible with the result that the contents of the cells are practically still and there is little or no evidence of banking. The resulting current efficiencies have been very high.

The capacity of each cell is more than 400 lb. of aluminum per day. The furnaces are tapped for molten metal every third day or when there is from 3 to 4 in. of metal. However, a metal pad of an inch or more is left on the bottom. Crucibles are brick lined and hold 3,000 lb.

Crucibles of molten metal are carried by trucks to the casting building which has two cell buildings on one side and three on the other. The 52 lb. pigs of aluminum are stored in the yard waiting tests. They are later moved to the adjacent rolling mill.

In any aluminum plant the rectifying equipment for changing a.c. power into low voltage, high amperage d.c. power is a most important factor in reducing aluminum. The rectifier station at Listerhill consists of a substation where high voltage power received from nearby Muscle Shoals powerhouse is transformed down to 13,800 volts, with voltage regulation through auto-transformers. The power comes into the rectifier building proper to metal clad switchgear, at ground level. The rectifying tubes are located on the second floor. Underneath each bank of tubes is a heat exchanger which is served by a cooling tower located adjacent to the rectifying building. Each bank of rectifiers feeds onto a collector bus through a high speed breaker. The buses are feathered to maintain a constant ampere density per square inch throughout the length of the bus. The rectifiers are located adjacent to the ends of the reduction units so that a minimum drop in voltage is attained. Automatic power control and current control are provided.

ROLLING MILL

The Reynolds Alloys Co.'s plant is located adjacent to the aluminium plant and continues the straight-line flow of materials, which commenced with the arrival at the plant of the ore. It consists of a sheet rolling mill, and a shape and structural mill.

The pure aluminum pig from the reduction plant is alloyed with copper, manganese, magnesium or other metals in large reverberatory open hearth furnaces. The alloys are cast into sheet rolling blocks and rod rolling blocks.

Alloy sheet rolling blocks are homogenized in large furnaces at 900 deg. F. for several hours. They are next bloomed on a mill and their thickness reduced 30 percent. After cooling the faces of the slabs are scalped clean. Each face is then clad with a slab of pure aluminum equal to 5 percent of the thickness of the rolling block. This sandwich is reheated and the pure aluminum plates are welded to the alloy metal by a sticking pass through a rolling mill. After pressure welding the coating, the block is hot rolled as one metal into a coil. These coils, after hot rolling, are annealed and cold rolled to the desired gage of the finished sheet. Coils are cut into sheets and are then either heat treated or annealed. Heat treatment consists of heating sheets to 900 deg. F. and soaking for several minutes. The sheets are quickly quenched in cold water. This operation gives the material its strength. Sheets may be annealed at 650 deg. F. and air cooled. Annealing relieves rolling strains and produces a ductile sheet, easy to form and press.

Since the tremendous increase in volume necessitated by recent war demands, the aluminum fabricators have been forced to adopt rolling practices and handling technique similar to those used in the steel industry, and the trend in manufacture appears to be following steel very closely.

In the structural shapes and bar mill, after the square rod ingots have been homogenized, they are rolled on a shape and structural mill into rods or shapes of various diameters. This rolling process consists of rolling the ingot through a shape mill, taking it from a square to a round in a series of passes. Frequent roll changes are necessary in order to finish various sizes and shapes which are required by the aircraft industry. After rolling to the proper diameter or shape, the material is heat treated and water quenched to give it strength, or is sold in a rolled condition to be forged into pistons, cylinder heads, propellers, etc.

A program of continually improved practice has been adopted and is at present under way. This begins to be evident in the ingot casting with a constant upward growth of the open hearth furnaces, and the ingot size, which is 70 percent larger than formerly. Furnace size has increased correspondingly. Auxiliary furnaces for intermediate and final heat treatment are being designed and installed to handle in some cases, double the quantity of the original equipment. Plant capacity has more than doubled the original estimates and is still moving upward.

Additional rolling mills for strip are being erected. And another stand is being added to the rod and bar mill with the necessary auxiliary equipment so as to double the capacity to meet the increased demand of the aircraft industry for forging stock for propellers, cylinder heads and pistons.

Present expansions envision a total production about four times the original intent and judging from the present tempo of activity the final figure will be even higher.

Thus May 18, 1943, the second anniversary of the "completion" of the Listerhill plant of the Reynolds company finds that while alumina, aluminum, and sheets, rods and shapes have been made for the airplane industry for two years, the plant has been greatly expanded and the end of the growth is not yet in sight. Mr. Reynolds' keen foresight in 1940 has resulted in a plant which is constantly increasing the American supply of light metals for war uses.

For further information about the alumina and reduction departments of the Reynolds' plant at Listerhill, Ala., the reader is referred to the pictured and diagrammatic flowsheet on pages 154-157 of this issue.

Molten aluminum is cast into 52 lb. pigs and moved to adjacent rolling mill

Drawing off from a cell the first aluminum ever made in State of Alabama

The rolling mill produces aluminum sheets, rods and shapes for aviation

PROCESS EQUIPMENT NEWS

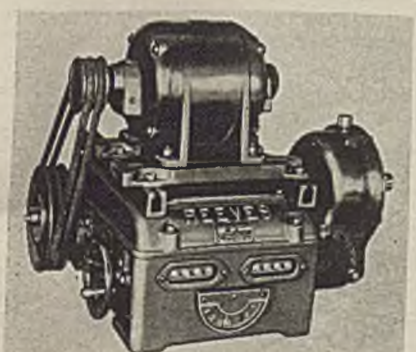
Compact Drive Unit

A NEW UNIT in the line of variable-speed control equipment manufactured by Reeves Pulley Co., Columbus, Ind., includes a combination of a variable-speed transmission with a built-in speed reducer. An important advantage of the new unit, which is shown in an accompanying illustration, is that it requires far less mounting space to obtain lower speed ranges than was formerly required when it was necessary to use auxiliary speed-reducing equipment. This reducer-type transmission is available in two inclosed designs, horizontal and vertical, in a wide range of output speeds and in capacities from 1 to 7½ hp. inclusive. The transmission itself produces ratios and speed variations from 2 to 1 through 12 to 1 and the reduction gears provide ratios up to and including 6.9 to 1. The gear reduction unit was designed especially for the severe torque demands of variable-speed service. It is of the helical-gear type, with all rotating parts splash lubricated.

Eye-Protective Glass

A NEW COMPOSITION of glass is available, said to be particularly effective in protecting the eyes of gas welders. The new glass, known as Didymium-Noviweld, is stated to permit the welder to see exactly what he is doing. The new glass possesses all the ray-absorptive properties of this company's Noviweld glass, plus the special characteristics of Didymium, a combination of elements with high absorption in the particular portion of the visible spectrum where "flux-flare" normally obstructs clear vision. Goggle lenses produced from this glass are said to cut down the high intensity sodium rays produced by the fluxes. In addition to their value in improving welding operations through better visibility, their protection of the welder's eyes against the tiring and harmful effects of ultraviolet and infrared rays is said to be an important factor. The new glass is available in three shades.

Compact variable-speed reducer unit

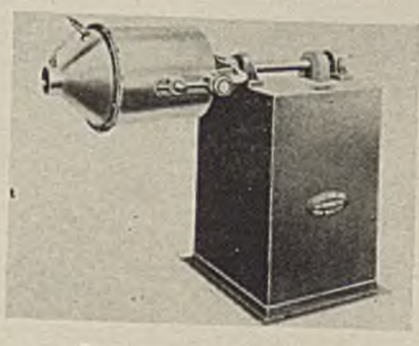


New lenses for gas welding

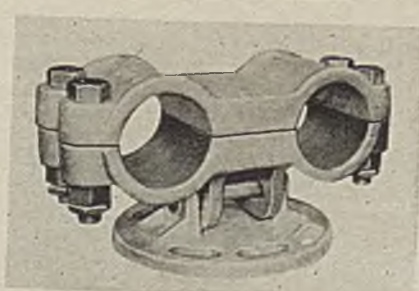
Special Processing Mill

A SPECIAL MILL for grinding, mixing or compounding of relatively small or moderate size batches of wet or dry materials has recently been developed by Abbé Engineering Co., 50 Church St., New York, N. Y. The mill proper is a metal jar or container made of any desired material in any desired capacity, having a cone-shaped cover gasketed and bolted to it. At the end of the cone is a welded collar containing a special rubber-plug valve with a take-up lever working freely for charging and discharging the process material without removing the grinding balls. To remove the latter, the entire cone must be unbolted from the container. The container is mounted in a U-shaped metal frame and is equipped with fittings so that it can be tilted vertically with the valve up for charging, or down for discharging, while it is tilted horizontally for grinding or mixing. The shaft is supported on two ball bearings mounted on an inclosed welded base, with a roller chain drive extending from the shaft to the explosion-proof, gear-head motor mounted on a sub-base inside the housing.

Special grinding mill



Expansion type bus support



Bus Support Clamp

A NEW DEVELOPMENT to facilitate the use of multiple conductors of smaller diameter, instead of single larger conductors in the present emergency, is the expansion type bus support clamp recently announced by Delta-Star Electric Co., 2400 Block, Fulton St., Chicago, Ill. This cast clamp, shown in the accompanying illustration, provides for longitudinal movement of bus conductors due to expansion or contraction. The fittings have rollers permitting ⅝ in. longitudinal movement on either side of the centerline, or 1¼ in. total movement. Use of this type of fitting is said to reduce the possibility of insulator breakage on long bus runs.

Small Fork Truck

FOR HANDLING loads of 2,000 lb. and less with speed and safety, the Yale & Towne Mfg. Co., Philadelphia Division, Philadelphia, Pa., has developed a new bantam sized telescopic lift truck of the tilting fork type known as Model KM30-2. The truck is of the center-control type and measures only 98 in. from the stern to the tip of the 30-in. forks. Thus the truck is able to navigate speedily around sharp corners and in narrow aisles. With a single fork-height lift of 71¼ in., the machine adds an additional telescopic lift reaching to 129 in. Four forward speeds and an equal number of reverse speeds are provided. All controls are easily accessible and the hoisting and tilting controls are fitted with mechanical limit safety stops. The central position for the operator assures his protection, as well as perfect visibility in all directions.

Equipment Briefs

EISLER ENGINEERING Co., 740 South 13th St., Newark, N. J., has developed a new type of air-cooled distribution transformer which, presenting no explosion or fire hazard, can be located anywhere indoors without need for a protective vault. The unit is lighter and more compact than its liquid-filled counterpart, thus facilitating installation and requiring less floor space. Transformers of this line are constructed with heat-proof insulation including fibre glass, mica, asbestos and porcelain. They are furnished in various capacities up to 500 kva., in voltages to 4,800 volts, for 1- and 3-phase service.

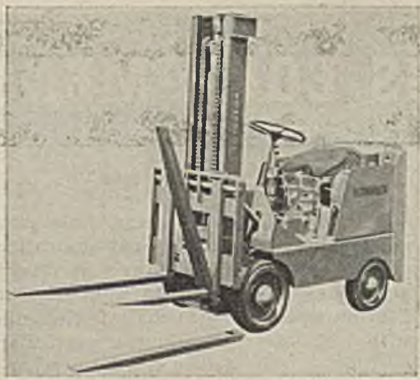
For protection of the skin of workers against industrial dermatitis, Mine Safety Appliances Co., Braddock, Thomas and Meade Sts., Pittsburgh, Pa., is marketing a series of industrial skin creams and lotions under the name of Fend. These creams and lotions are stated to provide a protective barrier on the skin against many specific hazards in industry. Each of the six different types provides protection against a number of specific skin hazards. The creams are said to be bland and neutral, offering no interference with normal action of the skin glands. They are readily removed with mild soap and warm water.

A line of washable paper dust masks and caps for protection against nontoxic nuisance dusts is being offered by Aldine Paper Co., 373 Fourth Ave., New York, N.Y. These caps are produced from a vegetable fibre paper product which can be stitched, washed and ironed like fabric. The tiny pores of the paper permit free and unhampered air passage but keep out dust. These caps and masks are said to be inexpensive enough to be disposed of after use, yet may be washed for re-use if necessary.

An industrial "can opener" for increased safety and for reducing the time required in opening light- and medium-weight drums has been announced by Industrial Products Co., 2820 North 4th St., Philadelphia, Pa. This new safety drum opener is said to cut smoothly, quickly and evenly and to fold in the cut edge close to the side of the drum for added safety. Operation of the tool is simple, requiring only a series of downward strokes similar to a can opener. When the head is entirely cut through, it is removed by grasping with the beaks of the tool. The tool is made of steel drop forgings, hardened and tempered for long life.

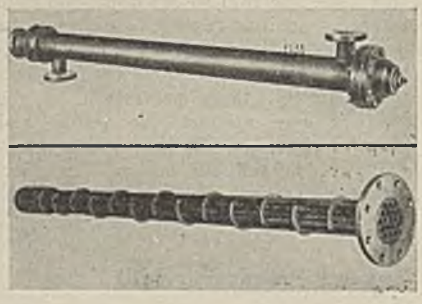
Eclipse Air Brush Co., 400 Park Ave., Newark, N.J., is now offering its line of spray guns equipped with a new type of black plastic body. The new gun weighs ¼ lb. less than the aluminum bodied gun which it replaces. The plastic is said to have good chemical resistance and not to be affected by thinners, solvents, paint removers, etc. Several months of service under strenuous conditions are said to have shown the success of the new design.

To assist in the war effort, Keystone Carbon Co., 2006 State St., St. Marys, Pa., has extended its operations in powder metallurgy to include the production of small parts of special design and shape to eliminate machining operations. Numerous relatively complex metal parts can be produced, such as cams, eccentrics, levers, slide blocks and other small metal parts. Close tolerances are possible and parts so produced can be of controlled porosity, and pre-lubricated.



Fork extension adapter

Heavy-duty swivel caster



Standardized heat exchanger unit

Fork Extension

To permit handling loads of widely varying dimensions with any lift truck having standard length forks, the Towmotor Corp., Cleveland, Ohio, has developed a new fork extension adapter which is quickly and easily attached over the regular truck forks as shown in an accompanying illustration. These adapters safely extend the fork length as much as 24 in., permitting skids or pallets of greater than minimum size to be handled efficiently by the same truck. The construction, as illustrated by the separate fork extension, automatically locks the extension in position against the vertical element of the fork.

Emergency Lighting Unit

Designed especially to meet the needs of war plants, arsenals and other war-time industrials for emergency lighting, the new Exide Lightguard emergency lighting unit has recently been announced by the Electric Storage Battery Co., 19th St. and Allegheny Ave., Philadelphia, Pa. The unit requires no fixtures or wiring other than plug-in connections to the a.c. supply. It throws a beam of light 50 ft. wide a distance of 100 to 200 ft., covering an area of 7,500 sq.ft. As pointed out by the manufacturer, when power lines are loaded to capacity, plant feeders in many cases are overloaded and need only a slight upsetting load condition to produce a lighting failure. When lights go out and machinery continues to run on momentum, this new unit automatically switches on its broad beam of light, helping to reduce accident hazards. Its effectiveness is said to be particularly pronounced in crowded areas, as well as in plant gatehouses, entrance and exit locations, first aid stations and plant dispensaries. Operation is entirely automatic, the only maintenance required being the addition of water occasionally to the battery. Recharging is done automatically by a trickle charger, the state of charge being indicated clearly by pilot balls.

Standard Exchanger Unit

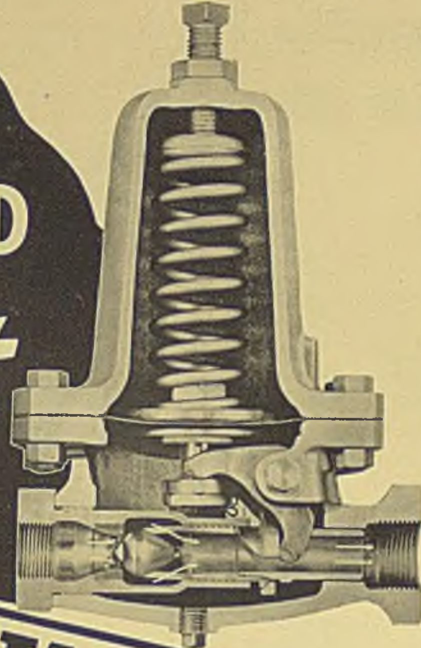
To permit the building of heat exchanger units on a production basis, Downingtown Iron Works, Downingtown, Pa., has developed the Shellfin, a standardized heat exchanger said to be suitable for most uses. With only minor changes in its basic construction, such as baffle spacing and length combinations of units, this design can be used for many applications of heat exchange between two fluids in the medium temperature range where the temperature of one fluid materially exceeds that of the other. The design is said to be adapted particularly well to cooling, heating, condensing and evaporating operations.

Standardized construction is said to eliminate much usual preliminary engineering, since with standardized performance pressure curves, unit selection can readily be made, giving results said to be fully equal to those obtainable with "custom-built" heat exchangers.

Swivel Caster

For heavy-duty applications, H. L. Pitcher Co., sales agents for Rose Mfg. Co., 12,400 Strathmoor, Detroit, Mich., has introduced an all-steel swivel caster of anti-friction design. The caster employs a drop-forged base plate with the king pin integral. Around the king pin is a roller thrust bearing and on the axle a cylindrical-roller-type anti-friction bearing. The caster swivels on ⅜-in. chrome steel ball bearings riding in a removable heat-treated steel race. Instead of cylindrical-type bearings, Oilite oilless bearings can be furnished if desired.

PUT IT ON THE LINE AND *Forget it*



CASH STANDARD *Streamlined* PRESSURE REDUCING VALVE TYPE 1000

Streamlined
FOR SMOOTH EVEN FLOW
of Steam, Water, Air, Oil, Etc.

● That is the Streamline story in a nutshell. The way it works is the answer—from inlet to outlet the fluid flows through this valve in a straight line—a streamline. There is no detour around a dividing wall—the direction of the flow is not changed at right angles because of a seat wall AND the flow is not broken up by valve stems, springs, or other parts. Forget it once it's installed like others do. PROOF: "We have a large number of buildings scattered over about 100 acres of land. Just where we installed these Streamlined Valves I dont know. But I do know that I haven't seen or heard of them since they were installed."—Case No. 343. PROOF: "We installed four or five of your Streamlined Regulators. The last I heard of them they were holding pressure the same as when we first installed them. And as far as I know no one has ever touched them." —Case No. 345.

Bulletin 1000 will give you full details.

YOU GET MAXIMUM CAPACITY WHEN IT IS NEEDED MOST

TROUBLE-FREE SERVICE	CONSTANT DELIVERY PRESSURE
SMOOTH OPERATION	PRACTICALLY ZERO IN MAINTENANCE COST
TIGHT CLOSURE	SPEEDIER PRODUCTION RESULTS
NO SPOILAGE	COST-SAVING OPERATION

ACCURATE PRESSURE CONTROL AT ALL TIMES

CASH STANDARD
CONTROLS . . VALVES

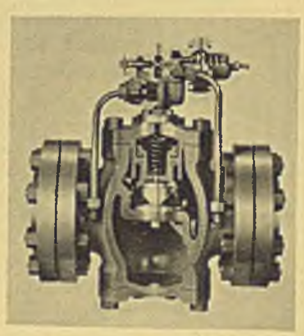
A. W. CASH COMPANY
DECATUR, ILLINOIS

OTHER VALVES *from the* CASH STANDARD LINE

Cash Standard Type 4190 Valve; holds constant back pressure on inlet side regardless of variation in outlet pressure or changes in load. A multiport, large capacity valve. Used on suction line in refrigeration practice. Also as bypass valve for oil pumps.

Iron or bronze bodies; iron trim. Screwed ends ½'' to 2''; flanged ends 2'' to 6''

In automatic liquid level work, Cash Standard controls: (1) to hold the level within the closest kind of limits; (2) to do it dependably. In the cut above, a Type 100-L Controller operates a 12'' Balanced Valve regulating liquid supply to a large tank. It is pilot actuated for sensitivity. It has operating power to spare—for any size Valve, however large.



Cash Standard Type 10 Pressure Reducing and Regulating Valve—self-contained, pilot operated. For holding reduced pressure within extremely close limits.

Sizes: 2'' to 12'' inclusive. Highest initial pressure 600 lbs.; highest reduced pressure 250 lbs. For use with water, air, Freon, ammonia; or with any non-corrosive gas or oil. Valve operating fluid not wasted; it discharges to outlet pipe. Bodies: iron, bronze, steel. Trims: Iron, bronze, stainless steel, monel.

☆

From Bauxite to Aluminum Sheet

A
Chem & Met
FLOW SHEET

Here is an aluminum plant that is unique for it starts with bauxite ore and carries through to sheets, rods and shapes for the manufacture of airplanes, all "under one roof."

Bauxite is ground with return caustic liquor from the evaporators in a closed circuit with a single deck classifier. Leaving the classifier as a fine pulp, the slurry is pumped to two horizontal continuous digesters. Digester detention provides about three-quarters of an hour for extraction of alumina and desilication of resultant liquor. The dilute pulp mixture is introduced into three primary thickeners from which relatively clear alumina liquor overflows. The settled solids are reintroduced into washing thickeners which wash the red mud. The last alkaline alumina liquor is washed from the red mud on Oliver filters before the mud is sent to the waste pond. The combined liquor overflow and wash liquors from the thickeners and washers is sent to storage. The unclarified hot liquor is passed through Vallez filters. Cooled and clarified strong alumina liquor is treated in precipitation tanks with fine aluminum hydrate from the seed tank. Hydroseparators perform a rough classification. The coarser solids are freed of a part of the alkaline liquor in three-deck washing classifiers. The partly washed hydrate feeds Conkey rotary vacuum hopper dewaterers where hot water removes the last of the soluble alkali from the finished hydrate. Alumina is then calcined and stored in silos. Reduction to the metal takes place in rectangular Soderberg continuous electrodes. The bath is composed of cryolite with additions of other fluorides and 6 to 8 percent alumina. It operates at 950 deg. C. Hoppers feed the alumina onto the crust through connecting pipe. It is added about twice during each 8 hr. shift.

The furnaces are tapped for molten metal every third day or when there is from 3 to 4 in. of metal. However, a metal pad of an inch or more is left in the bottom. Crucibles of molten metal are carried by trucks to the casting building. The 52 lb. aluminum pigs are stored in the yard waiting tests.

The pure aluminum pigs from the reduction plant are conveyed to the alloy plant which consists of a sheet rolling mill and a shape and structural mill. For further information on this aluminum plant, see pages 145-150 of this issue.

CHEMICAL & METALLURGICAL ENGINEERING
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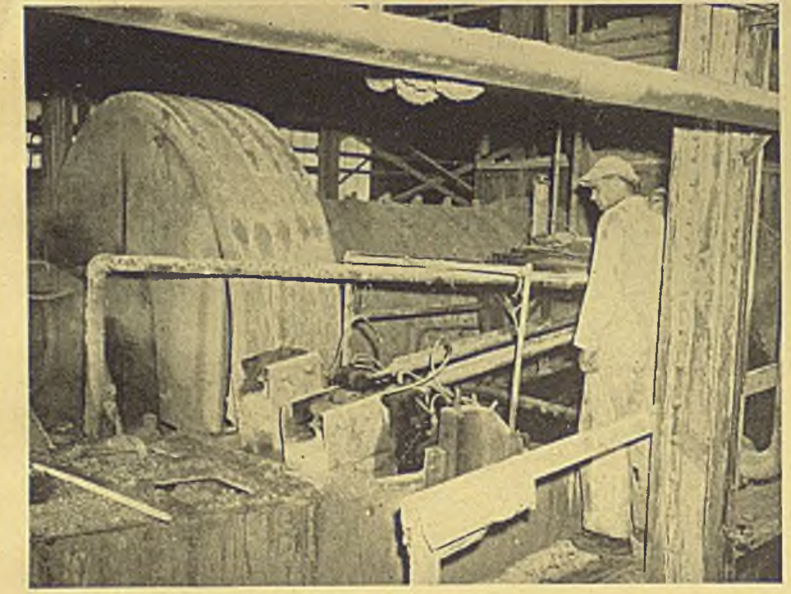
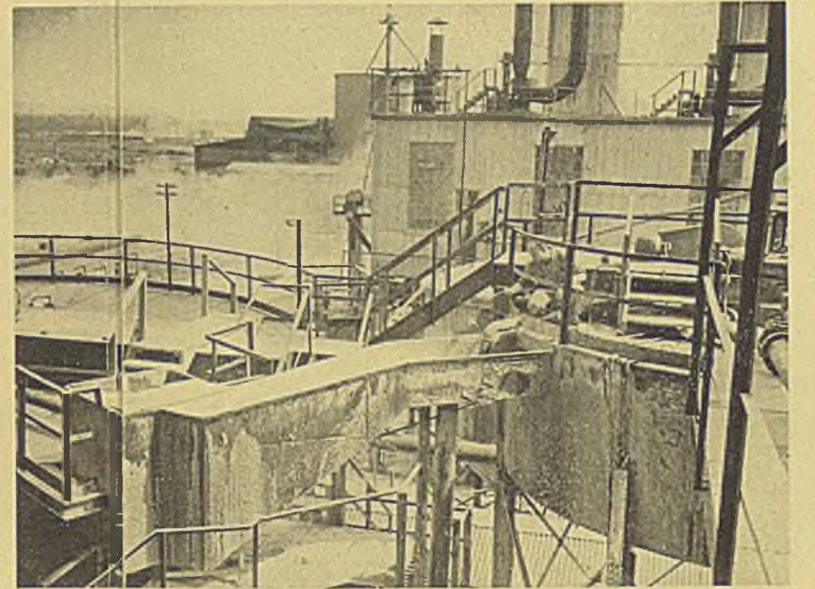
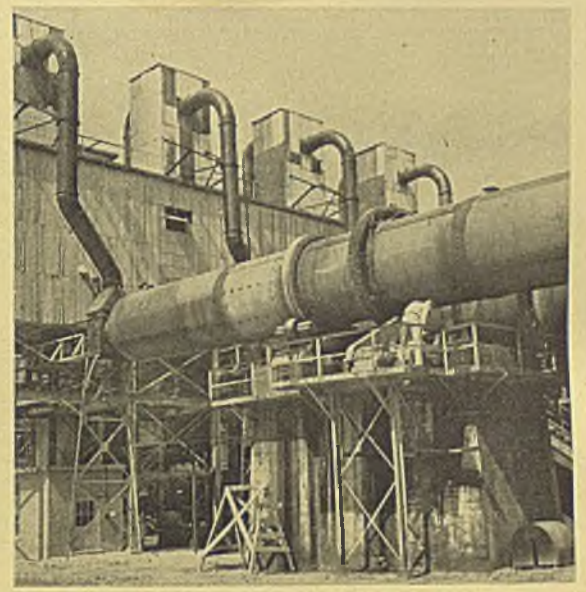
PAGES 154-157

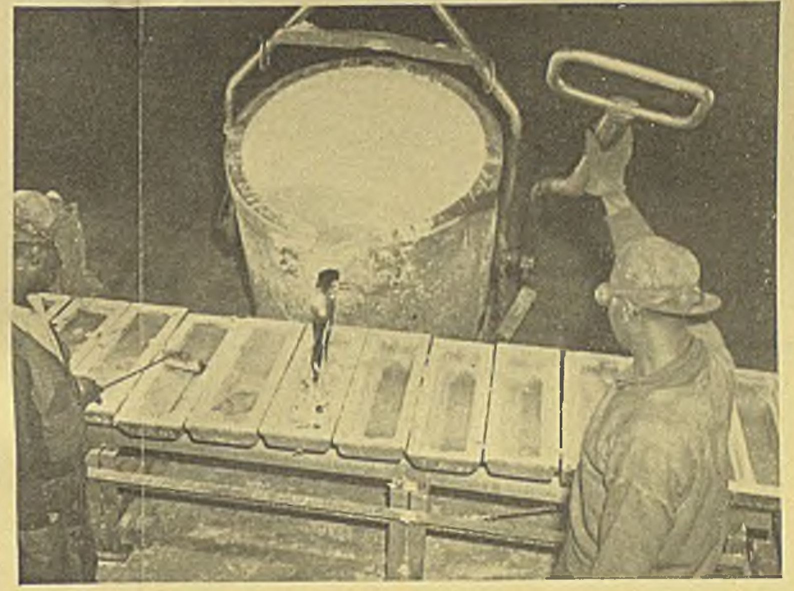

1 Bauxite and all other raw materials are received at the plant by railroad

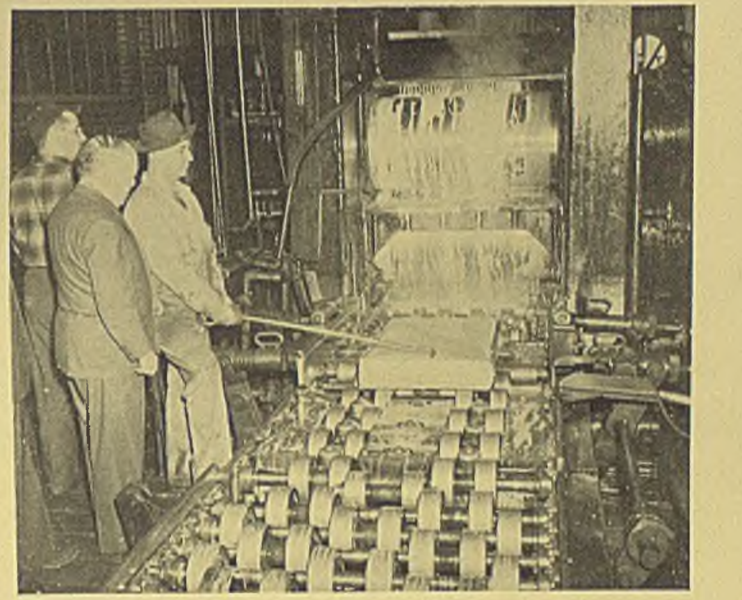

3 Wet grinding of ore is done with return caustic liquor from evaporators in a ball mill in closed circuit with classifier

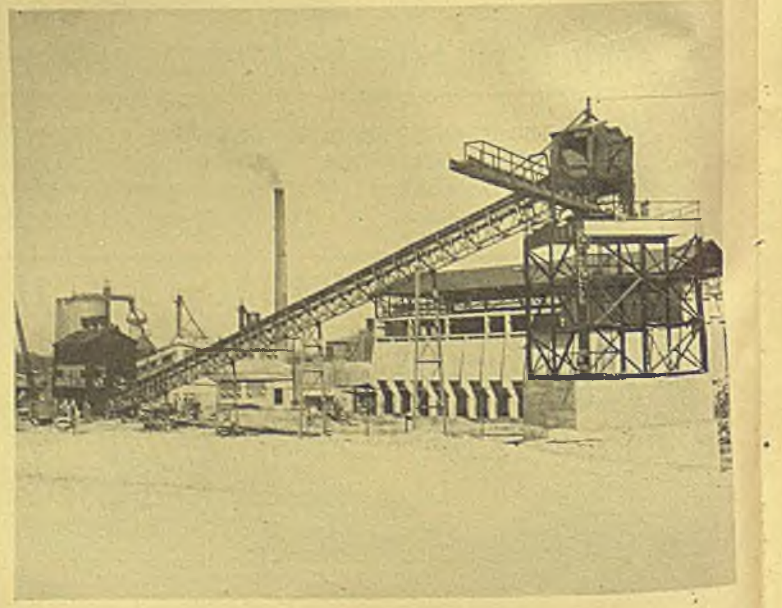

5 Remaining aluminate liquor is separated from the red mud on Oliver filters

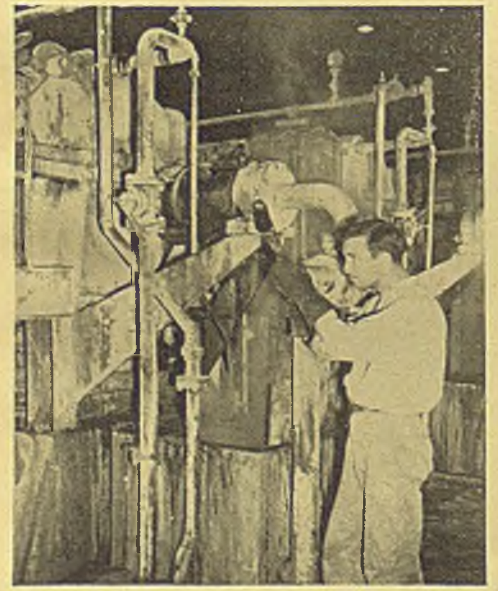

7 Hydroseparators perform a rough classification. Fines overflowing the hydroseparators are collected in thickeners

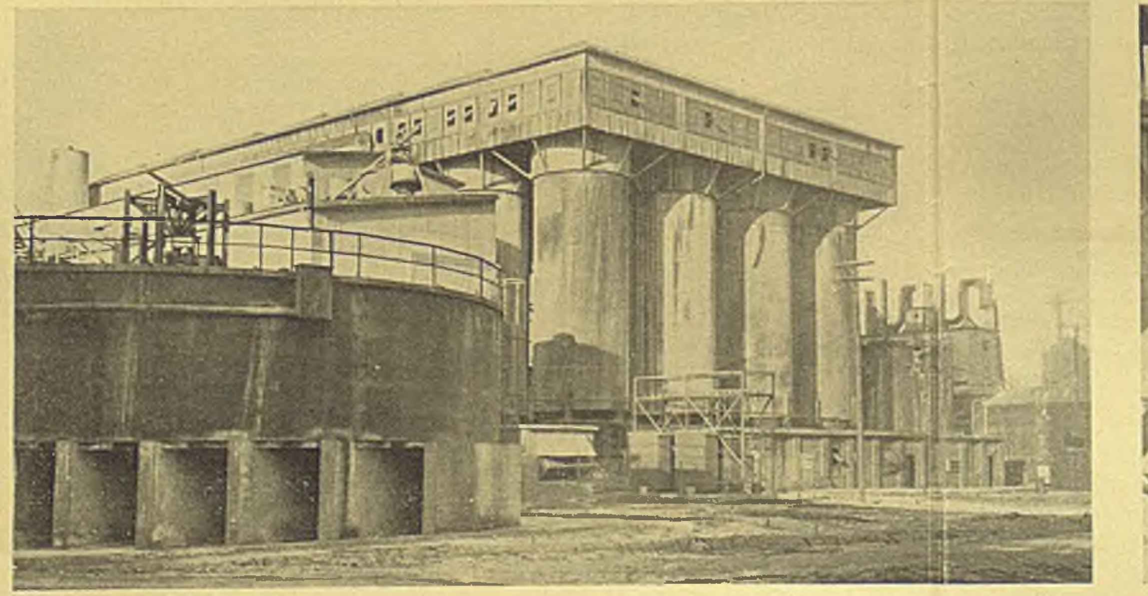

9 Washed cake containing 10 to 12 percent moisture is fed by horizontal screws into rotary kilns

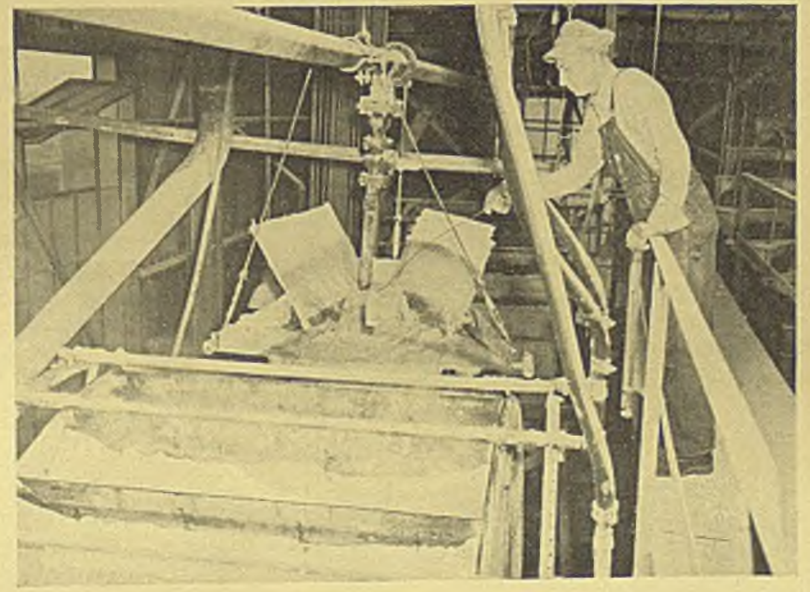

11 Crucibles are brick-lined and hold 3,000 lb. Molten metal is cast into 52 lb. pigs and transferred by truck to the yard outside

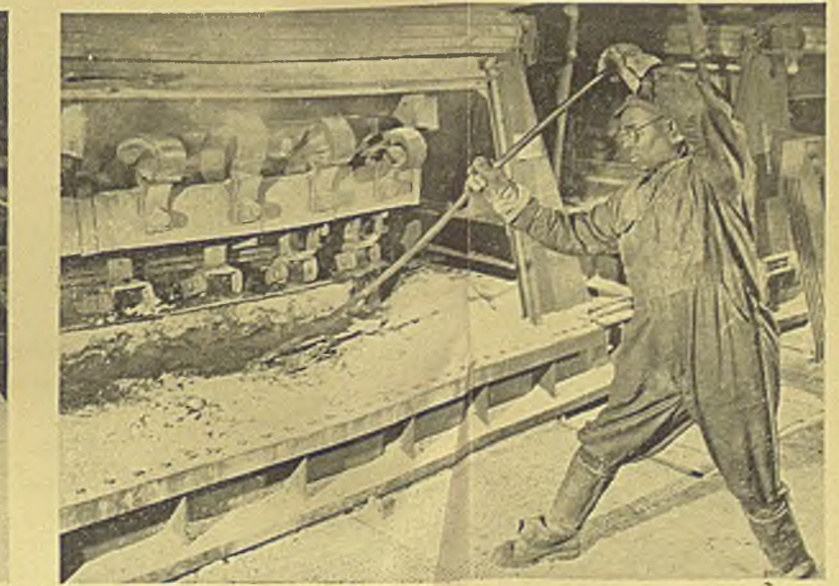

13 Pres. R. S. Reynolds inspects an alumin block in the rolling mill which continues a straight-line flow of materials

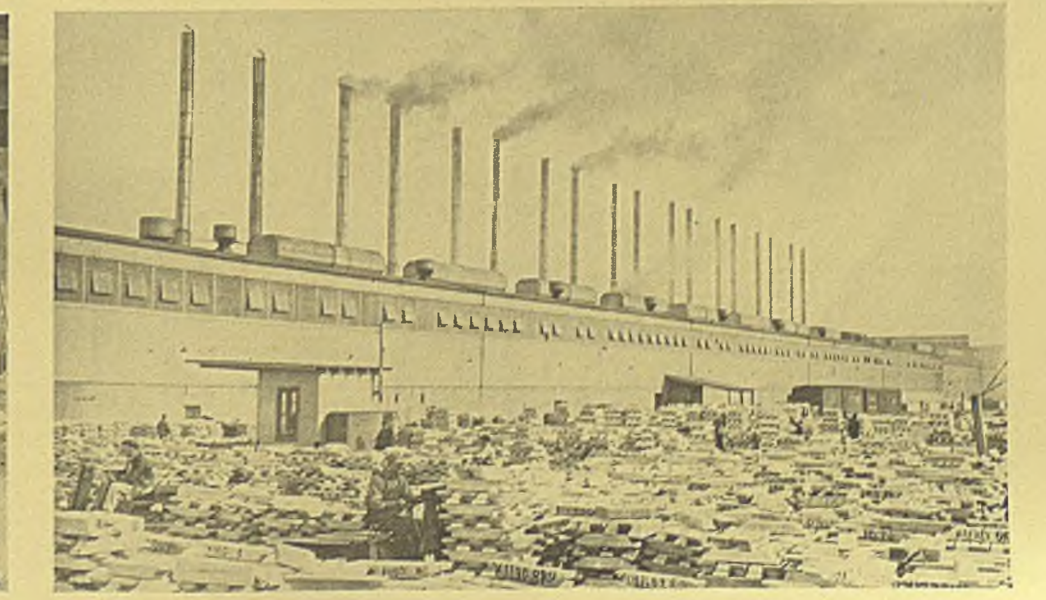

2 Bedding-down building is divided into two parallel bins providing under cover storage for four-days requirements


4 Unclarified hot storage liquor is pumped to a battery of eight Vallez filters


6 Cooled and clarified strong aluminate liquor is precipitated in a battery of twenty-eight 60 ft. high, straight-side tanks. Fine aluminum hydrate seeds are added to start precipitation

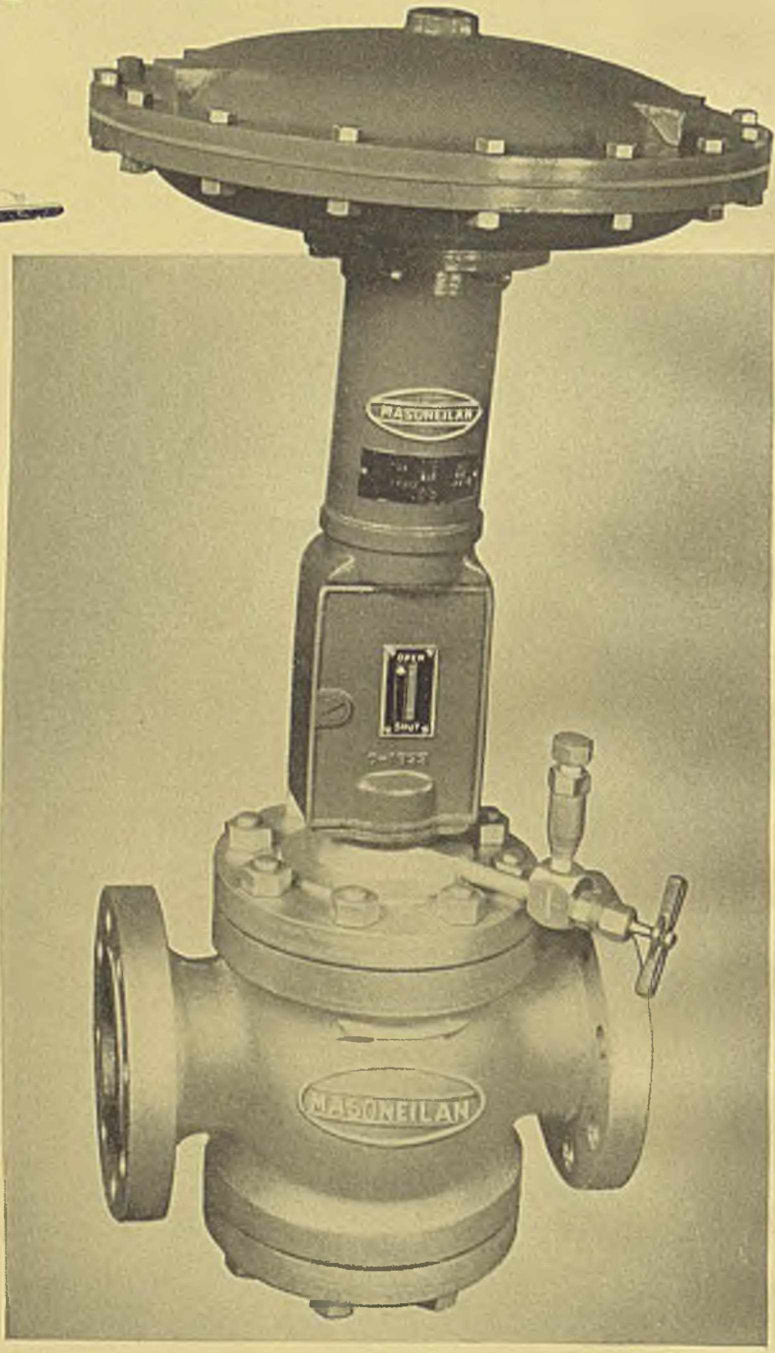

8 Fresh, hot water removes the last of the soluble alkali from the finished hydrate in Conkey dewatering filters


10 Rectangular Soderberg continuous electrodes are used in the cells. Cells are tapped for molten metal every third day


12 Aluminum pigs are stored in the yard waiting tests. They are later moved to the adjacent department consisting of a sheet rolling mill, and a shape and structural mill

There Can't Be Any Guess in this Gas*

*High octane gasoline used by our war-birds must be *right*. There can't be any guessing when not only life but victory is at stake. That's why automatic controls are so important in the petroleum industry.



AND that's why many refineries use Masoneilan Control Valves. Their performance and their sturdy construction have won them a top spot in the process industries.

Which in turn is why some of our friends may not have been able to get these valves when they wanted them. Naturally the most vital war-winning plants come first. If you have been disappointed remember that Masoneilan valves probably have helped produce much of the high octane gas that, night and day, propels our planes over Hitler-land with presents for Adolf.

MASONEILAN

Mason-Neilan Regulator Company

Boston, Massachusetts

He'll Learn Faster From These Practical *"PIPING POINTERS"*

Millions of "green" war workers are willing and ready to learn. But it's up to you and us to give them practical aids for doing a better job.

In hundreds of plants today, training of maintenance crews is being speeded by Crane "Piping Pointers." These bulletins, based on Crane's 88-year experience in the flow control field, are aimed at a single purpose: to keep pipe lines—*your plant's lifelines*—operating at peak efficiency.

"Piping Pointers" give practical aid to veterans as well as beginners. They're full of *do's and don'ts* and *rights and wrongs* of sound piping practice. They show proper valve selection—installation short-cuts—correct repair procedures—substitutions to solve material shortages—and safety hints. Anyone can understand and use them.

SENT FREE TO ANY PLANT

For Victory's sake, faster training of workers for better maintenance of piping is a vital *must.* In "Piping Pointers," Crane Co. shares its basic information for that use, with all industry, and offers these bulletins free to any plant. Ask your Crane Representative or write direct for your supply. Crane Co., 836 South Michigan Avenue, Chicago, Ill.

ARMY NAVY

CRANE VALVES

Chemical Engineering NEWS

CHEMICAL EXPOSITION MOVES TO MADISON SQUARE GARDEN

Having obtained enthusiastic approval of almost 90 percent of the firms responding to the announcement from those that exhibited at the last Chemical Exposition in New York in 1941, Charles F. Roth, Manager, Exposition of Chemical Industries, announced early in May that the 19th Exposition of that series will be held at Madison Square Garden in New York, December 6-11, 1943. The change in place results from the fact that the United States Army has commandeered the exposition floors of Grand Central Palace as an induction center and, after careful study, it has been found that the Garden is the only building remaining available in New York which has the space and facilities for accommodating this type of exposition.

The actual amount of space available will be approximately one-half of that used at the time of the 1941 Exposition. All space will be upon one floor, however, and the management reports that accommodations may be had for booths varying in size from 8x11 to 22x14 ft. A few booths of even larger size will probably be available.

Expositions of process equipment and materials having to do with the prosecution of the war have proved exceedingly helpful wherever they have been held in this country or abroad. Many exhibitors welcome such an opportunity to display products now going into new war plants, but which will find important applications in peacetime industries once the present construction program has been completed. Chemical engineers and other technical men concerned with increasing present production and looking ahead to new uses for wartime surplusses find that these expositions are profitable sources of ideas and inspiration.

Exact floor plans for the 19th Exposition of Chemical Industries are not yet available but, according to the management, these facilities will provide ample opportunity to bring together a record number of makers and users of chemical engineering materials and equipment.

CHINESE ENGINEERS WILL STUDY AMERICAN TECHNIQUES

Thirty-two young Chinese engineers have arrived in this country to study American engineering techniques according to an announcement made by the Board of Economic Warfare. Eight of the group have taken training positions with the Tennessee Valley Authority and the rest are with domestic industrial firms. Positions have been found for three others who are still in China or on their way to this country. These young men will work here for two years in fields which in most cases they selected as their major interest. Each has had advanced training in Chinese technical schools and actual experience in his chosen field.

Those interested in chemicals and related products, their special fields, and their places of training include: L. C. Hui, nitrogen products, Tennessee Valley Authority; S. T. Yeh, chemical machinery, Buffalo Foundry & Machine Co., Buffalo; T. T. Kung, dyestuffs, General Aniline Co., New York; C. Hsuan, coke ovens, Koppers Co., Pittsburgh; S. Y. Hsiung, petroleum refining, Standard Oil Co. of N. J., Elizabeth; and H. C. Yuan, copper, lead, and zinc refining, Phelps Dodge Co., New York.

ROHM & HAAS COMPLETING NEW ACRYLONITRILE PLANT

Construction of a second plant for the manufacture of acrylonitrile, a vital organic constituent of the Buna-N synthetic rubbers, was announced today by Rohm & Haas Co., Philadelphia. The new $300,000 plant, which is expected to be completed early this year will bring to four the number of acrylonitrile plants in operation in this country.

Rohm & Haas' first plant, opened in 1940, was a result of several years interest in the possibilities of acrylonitrile as a copolymer with butadiene in the Buna-N synthetic rubbers, an interest aroused by long experience in the production of acrylics for Plexiglas transparent plastic and for leather and textile finishings.

Shortly after our entrance into the war in 1941, many months before it was officially decided which one of the synthetic rubbers available would be developed on a large scale, Rohm & Haas presented to the Government, plans for building a large capacity acrylonitrile unit.

Use of these specialty type synthetic rubbers increased to the point where late last year it became evident that acrylonitrile units would require expansion. Rohm & Haas was asked to build a second, larger plant, and having plans already completed was able to make an immediate start. To save critical materials in construction, most of the equipment in the new unit is being erected out-of-doors, following the principles of construction generally used in the petroleum industry.

GULF OIL COMPLETES REFINERY FOR AVIATION GASOLINE

J. Frank Drake, president of the Gulf Oil Corp., announced last month the completion of a new Houdry catalytic cracking unit for the production of 100-octane aviation gasoline at the company's refinery at Port Arthur, Texas. The completed unit is a part of Gulf's aviation gasoline program being carried out in cooperation with the Government. This unit was rushed to completion with the aid of a directive of the War Production Board. It was entirely financed by the Gulf Oil Corp., which to date has expended something like $15,000,000 on increasing its aviation gasoline facilities at Port Arthur. The entire output of these facilities is supplied to the fighting forces, being under contract to the Government.

NEW POTASSIUM CHLORATE PLANT IN OPERATION

At the beginning of the month, R. B. Wittenberg, manager of the chemical department of International Minerals & Chemical Corp. of Chicago, announced that production of potassium chlorate had been started at the company's new plant at Columbia Park, Cincinnati. The plant obtains its muriate of potash from the company's mine at Carlsbad, N. M. John H. Merriam is superintendent of the new plant which occupies a small portion of a 20-acre plot, providing space for future expansion.

GOVERNMENT UNIT STUDIES ALIENS' PATENTS

Uncle Sam is trying to practice what he preaches. He has set up in the office of the Alien Property Custodian a unit to study the seized patents owned by aliens with a view to using these in the war effort. Dexter North, chemical consultant of Washington, has been placed in charge of this work. Moreover, cooperation is being afforded by many Chicago chemists who are preparing abstracts of the patents to aid in their appraisal.

The government offices concerned with the war effort are being urged to examine every patent vested with A.P.C. to see whether there are not valuable wartime ideas that should be put to work for the cause of the Allied Nations. Any aid which industry can offer to this end will be more than welcome.

USERS OF CHEMICALS ASKED TO RETURN CONTAINERS PROMPTLY

Importance of getting returnable containers back to suppliers promptly in order to insure continued delivery of essential chemicals and allied products in wartime was stressed in a joint statement by the Chemicals and Containers Divisions of the War Production Board issued on May 1.

The statement pointed out that the request for prompt return of containers by the users applies to steel drums that formerly were considered non-returnable, fiber drums, slack wood barrels, tight wood barrels and cylinders. The Chemicals and Containers Division suggested that each user get in touch with his supplier to find out whether the supplier wants the containers back before making any other disposition of them. Containers should not be used by the purchaser of the chemical for other purposes without the specific permission of the supplier to do so, it was pointed out.

The following suggestions to users for returning drums were offered: Have your supplier pick up your empty drums when delivering full drums, or return empty drums to the works or warehouse from which received; deposit charge will be refunded upon receipt of drums in good condition; do not use pressure to empty drum; drums should be kept clean, but do not rinse; do not use for storage or shipment of any other material; in returning drums, replace and securely tighten both bungs; in returning open-head drums, do not interchange lids or lever locks. Be sure to return lock with drum; use proper size valves in order to prevent stripping of threads; do not tighten bung plugs excessively as this may rupture flange threads or loosen the spud which would ruin the drum; use faucet or spigot provided with straight threads equipped with resilient gaskets.

CANADA INCREASES OUTPUT OF STRATEGIC MATERIALS

New deposits and new processes together with discoveries by the prospector and the scientist are helping Canada to fill some of the gaps in the production of strategic materials needed in the war according to F. V. Seibert, industrial commissioner, Canadian National Railways.

In reviewing developments, Mr. Seibert places as one of the most important, the production of mercury in British Columbia. Before the war, Canada produced no mercury but now is one of the world's largest producers with an output about six times its own requirements. In 1940, Canada turned out less than one-half of one percent of its requirements of tungsten but when supplies from China were cut off, the home output was speeded up and last year accounted for 17 percent of consumption with a further gain in prospect this year.

Until a few months ago, there was no production of magnesium in Canada. Now a plant using the ferro-silicon process developed by a Canadian, Dr. Pidgeon, is supplying home needs and shipping quantities abroad. Production of brass is 17 times what it was in 1939. While chrome and manganese ores are imported, home requirements are met with respect to ferro-chrome, ferro-manganese, and ferro-silicon and Canada is the main source of supply of these materials for Great Britain.

ALLIED CHEMICAL & DYE CORP. CONTINUES FELLOWSHIPS

Allied Chemical & Dye Corp. announces continuation of its graduate fellowship plan in the school year 1943-44. Although the plan was conceived and established in peacetime, the company feels that in view of the valuable assistance in the war effort being rendered by well trained chemists and chemical engineers, aid to outstanding graduate students in completing their work for the Ph.D. degree is still of the highest importance. The recipients of the fellowships and the subjects are chosen by the universities; subjects are not restricted to those connected with the products or interests of Allied's operating divisions and subsidiaries. Stipend of each fellowship is $750.

FOR PRODUCTION EXCELLENCE

Among the companies which, in the past month, have been awarded the honorary Navy "E" and joint Army and Navy "E" burgee for exceeding all production expectations in view of the facilities at their command, are included the chemical and explosives plants, the chemical process industries and the chemical engineering equipment concerns listed below. Other process and equipment plants will be mentioned in these columns as the awards are presented to the individual plants.

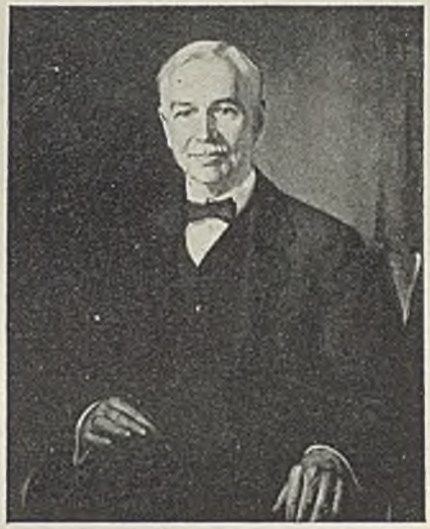
Allegheny Ludlum Steel Corp., West Leechburg, Pa.
Allis-Chalmers Mfg. Co., Supercharger Plant, Milwaukee, Wis.
The Alvey-Ferguson Co., Cincinnati, Ohio.
American Gear and Mfg. Co., Chicago, Ill.
American Electric Furnace Co., Boston, and Plant No. 2, Dorchester, Mass.
American Hydraulics, Inc., Sheboygan, Wis.
American Screw Machine Products, Inc., Chicago, Ill.
Ampco Metals, Inc., Milwaukee, Wis.
Atlas Powder Co., Ordnance Plant, Ravenna, Ohio.
Bernhardt Mfg. Co., Charlotte, N. C.
J. Bishop & Co., Malvern, Pa.
Blaw-Knox Co., Martins Ferry, Ohio, and Groveton, Pa.
Bronson Reel Co., Monson, Mich.
A. M. Byers Co., Byers Plant, Economy, Pa.; Southside Plant, Pittsburgh, Pa.
Century Engineering Corp., Cedar Rapids, Iowa.
Century Screw Co., Chicago, Ill.
Cleaver-Brooks Co., Milwaukee, Wis.
Climax Engineering Co., Clinton, Iowa.
Consolidated Packaging Machinery Corp., Buffalo, N. Y.
Crucible Steel Co. of America, Halcomb Works, and Emerson Avenue Works, Syracuse, N. Y.
Dahlstrom Metallic Door Co., Jamestown, N. Y.
Defiance Machine Works, Defiance, Ohio.
The John Douglas Co., Cincinnati, Ohio.
Dow Chemical Co., Bay City, Mich., Freeport, Texas, and Dow Magnesium Corp., Velasco, Texas.
Driver-Harris Co., Harrison, N. J.
General Ceramics and Steatite Corp., Plant No. 3, Keasbey, N. J.
General Electric Co., Everett, Mass.
The Geometric Tool Co., New Haven, Conn.
Gillette Machine Tool Co., Hollywood, Calif.
The B. F. Goodrich Co., Los Angeles, Calif.; Clarksville, Tenn.
Hawley Products Co., St. Charles, Ill.
Henry Heide, Inc., New York, N. Y.
Hughes-Keenan Co., Mansfield, Ohio.
Ben-Hur Mfg. Co., Main Plant, Milwaukee, Wis.
Frank Ix & Sons, Inc., Charlottesville, Va. and New Holland, Pa.
William F. Jobbins, Inc., Aurora, Ill.
A. D. Julliard & Co., Inc., Aragon Mills, Aragon, Ga.
I. F. Laucks, Inc., Plant No. 1, Seattle, Wash.
Lehigh Foundries, Inc., Easton, Pa.
Lifesavers Corp., Port Chester, N. Y.
Lindberg Steel Treating Co., Chicago, Ill.
Lombard Governor Corp., Ashland, Mass.
M & R Dietetic Laboratory, Inc., Columbus, Ohio.
Mahoning Valley Steel Co., Niles, Ohio.
Mason Silk Co., Winsted, Conn.
Merchant & Evans Co., Lancaster, Pa.
Monsanto Chemical Co., Longhorn Ordnance Works, Marshall, Texas.
W. F. Mosser & Son, Allentown, Pa.
National Battery Co., Depew, N. Y.
New England Tape Co., Inc., Hudson, Mass.
Northwest Metal Products, Inc., Kent, Wash.
Norwich Pharmacal Co., Norwich, N. Y.
Ohio-Apex, Inc., Nitro, W. Va.
Ohio Ferro-Alloys Corp., Philo, Ohio.
The Ohio Tubular Products Co., London, Ohio.
Patch-Wegner Corp., Long Island City N. Y.
Pennsylvania Salt Mfg. Co. of Washington, Tacoma, Wash.
Peerless Woolen Mills, Rossville, Ga.
Chas. Pfizer Co., Brooklyn, N. Y.
Proximity Mfg. Co., Greensboro, N. C.
Raytheon Mfg. Co., Equipment Division, Power Tube Division, Radar Division, Waltham, Mass.; Small Tube Division, Newton, Mass.
Reliance Mfg. Co., Beacon Plant, Loogootee, Ind.
Republic Drill and Tool Co., Chicago, Ill.
Revolution Cotton Mills, Greensboro, N. C.
Reynolds Research Corp., Container Division, Louisville, Ky.
Rheem Mfg. Co., No. 1 Plant, Chicago, Ill.
Rice Barton Corp., Worcester, Mass.
Rodney Milling Co., Kansas City, Mo.
Rogers Pattern and Foundry Co., Los Angeles, Calif.
Rustproofing and Metal Finishing Co., Cambridge, Mass.
Shakespeare Co. and Shakespeare Products Co., Kalamazoo, Mich.
Spencer Thermostat Co., Attleboro, Mass.
Standard Steel Spring Co., Coraopolis, Pa.
Stearns Mfg. Co., Adrian, Mich.
Stupakoff Ceramic and Mfg. Co., Latrobe, Pa.
Sullivan Machinery Co., Michigan City, Ind.
The Thresher Varnish Co., Dayton, Ohio.
Traylor Engineering & Mfg. Co., Allentown, Pa.
Trojan Powder Co., Sandusky, Ohio.
United Steel & Wire Co., Battle Creek, Mich.
United Welding Co., Middletown, Ohio.
Universal Engineering Co., Frankenmuth, Mich.
Universal Engineering Corp., Cedar Rapids, Iowa.
The Watling Mfg. Co., Chicago, Ill.
The Michael Yundt Co., Waukesha, Wis.

MANY CHEMICAL ENGINEERS IN ATTENDANCE AT A. H. WHITE'S BIRTHDAY PARTY

THREE hundred and fifty friends and neighbors, former students, faculty and professional associates of Prof. Alfred H. White joined him and Mrs. White in a dinner at the Michigan Union building in Ann Arbor on April 29 to celebrate his seventieth birthday. That date also signalized some fifty years of association with the University of Michigan, which gave him his first bachelor's degree in 1893, and in 1898 put him in charge of its course in chemical engineering. Except for M.I.T.'s, this is the oldest recorded curricula in chemical engineering in the United States, if not in the world.

From 1917 to 1942 Professor White was head or chairman of the department that has since become known as "Chemical and Metallurgical Engineering" (see accompanying graph prepared by Prof. Donald L. Katz). During this period some 2500 students have known Professor White as a teacher, guide and counselor. The annual enrollment has grown from a dozen at the turn of the century to almost 500 in the peak year, 1940, when over 160 degrees were granted.

Harvey M. Merker, superintendent of manufacturing for Parke, Davis & Co., and a member of the class of 1909, presided as toastmaster. Greetings were presented to Dr. and Mrs. White and to their daughter, Dr. Mary White, of New York City, by Michigan's President,



Recent portrait of Alfred Holmes White presented to the University of Michigan by a group of his former students

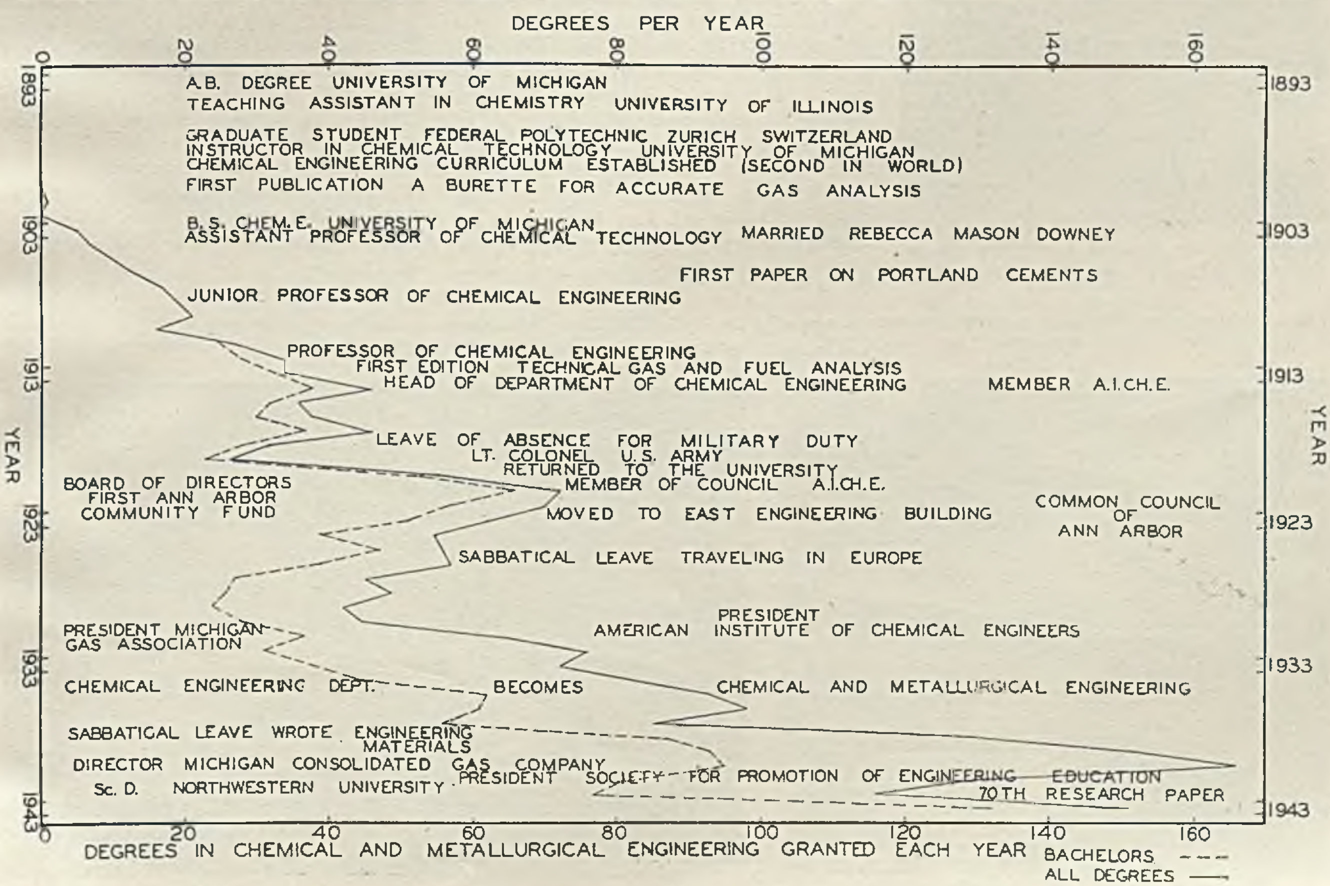
Professor White was born in Peoria, Ill., April 29, 1873 and studied for one year at McGill University in Montreal before receiving his A.B. degree from the University of Michigan in 1893. The same institution granted him a B.S. degree in chemical engineering in 1904 and last June he received the Sc.D. of Northwestern University. After serving one year as an assistant at the University of Illinois he studied under George Lunge in the Federal Polytechnicum at Zurich from 1896–7, returning to begin his long and fruitful career as a member of the faculty of the University of Michigan. Significant events are noted below.

Alexander Grant Ruthven, by James LeRoy Bennett of Hercules Powder Co. and president of the American Institute of Chemical Engineers, by Alfred H. Lovell, assistant dean, and Ivan C. Crawford, dean of the College of Engineering, by Ralph A. Hayward, member of the class of 1917, president of the Kalamazoo Vegetable Parchment Co. and newly elected to Michigan's Board of Regents, by George Granger Brown, of the graduate class of 1924 who in 1942 succeeded Professor White to the chairmanship of the department, by Sidney D. Kirkpatrick, editor of *Chem. & Met.*, and by Shirley W. Smith, vice president and secretary of the University, who is an intimate friend of Professor White and a contemporary on the Michigan faculty.

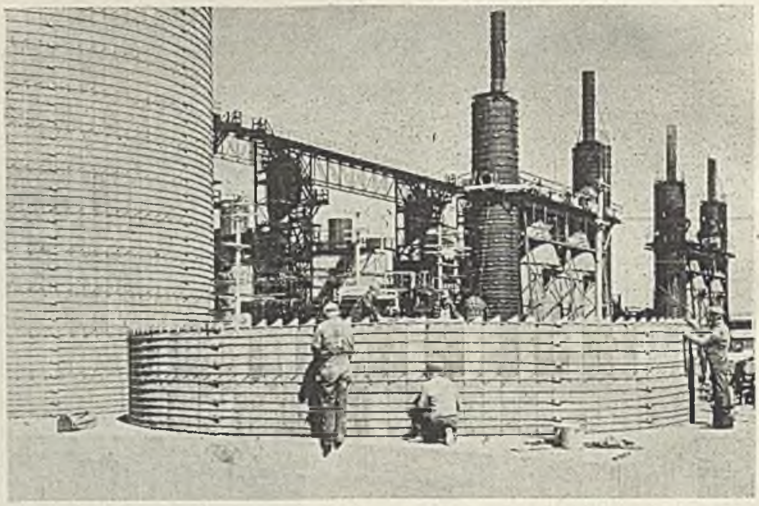
An impressive feature of this happy occasion was the official presentation of Professor White's portrait to the University. It was eloquently presented to President Ruthven by Roy A. Plumb of the class of 1906, who is president of the Truscon Laboratories, and who spoke for the large group of Professor White's former students that not only provided the funds for the portrait but also established a scholarship in the department of Chemical and Metallurgical Engineering.

Michigan's Men's Glee Club, led into the banquet hall by one of Professor Brown's stalwart sons, sang Happy Birthday and other appropriate songs. The ladies' committee headed by Mrs. Brown and Mrs. Katz, provided a delightful menu and beautifully decorated the tables and the banquet hall.

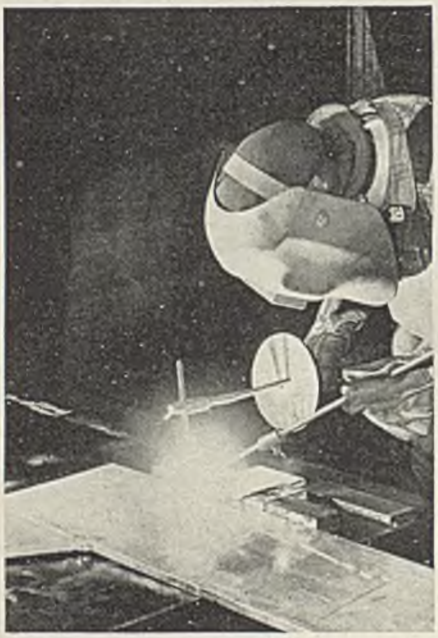
Development of Chemical and Metallurgical Engineering at the University of Michigan under Professor White's leadership, 1893-1943



Granular cell feed of anhydrous magnesium chloride is stored in huge concrete tile silos shown under construction



Silver Frees Copper to Make More Metallic Magnesium



Welder working on solid silver bus bar in new plant of the Dow Magnesium Corporation

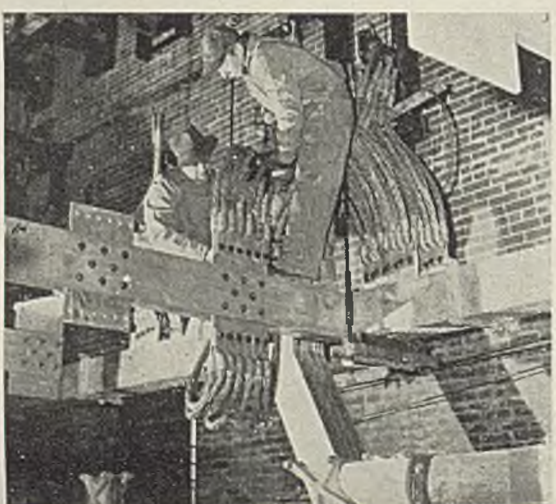
SILVER almost completely replaces copper in the power distribution lines of the newest Dow-process magnesium plant recently built by the Austin Company at Marysville, Mich. for the Defense Plant Corporation. Approximately two million pounds of the metal, valued at $20,000,000, have been loaned to the DPC by the U. S. Treasury in order that the equivalent amount of copper could go into shells, ordnance equipment and other war needs for which there is no adequate substitute.

Other features of the new plant, officially opened on April 8 by Dr. Willard H. Dow, president of the parent operating company, is the extensive use of wood and plastics where steel and other critical materials would normally have been used. A rigid frame concrete structure with a double hinged arch of exceptionally wide span, will house all of the alloying operations. Concrete tiles have been used in construction of the huge silos in which the anhydrous magnesium chloride cell feed is stored after having been shipped by railroad from the brine recovery plant at Ludington.

The brine from which the "cell feed" is made contains more than 10 per cent of magnesium chloride. It is drawn from nine wells, all located within 10 miles of the plant at Ludington. Here the brine undergoes chemical treatment to separate the magnesium chloride from other salts, which is then precipitated, filtered and crystallized. The Ludington plant includes a lime kiln, a power plant, carbonating and filtering units, evaporators, crystallizers and dryers. The site also includes ample dock facilities on Pere Marquette Lake to accommodate the largest lake freighters.

The anhydrous magnesium chloride is shipped to Marysville in closed hopper railroad cars and handled there in much the same way as wheat or corn. It is converted into metallic magnesium by the standard Dow process which was described in *Chem. & Met.* in November, 1941 (pp. 130-3). When in full operation these two complementary plants in Michigan will have an output equal to that of the largest of the sea-water magnesium plants which is now operating in Texas.

Starter cables being connected to silver bus bars in one of the magnesium cell buildings at Marysville, Mich.



Dr. Willard H. Dow looks on as an employee pours one of the first ingots of magnesium in fifth Dow-process plant built by Austin Company for D.P.C.

WASHINGTON NEWS

Civilian supply has become the No. 1 problem in Washington. Spurred by the threat of Congressional action which would set up a Civilian Supply Administration outside of WPB, Donald Nelson, WPB chairman, has appointed a new vice-chairman, Arthur D. Whiteside, to take charge of civilian requirements. Mr. Whiteside is no stranger to the National Capital. In his new position he gives to civilian supply an able champion who knows the devious ways of bureaucratic Washington and who can shout on equal terms with the Army, Navy and other claimant agencies for the things necessary to keep our industrial plants going.

In another quick move WPB Chairman Nelson asked the President to add three important government officials to the War Production Board. The appointment of War Manpower Chairman McNutt, Office of Defense Transportation Director Eastman, and Petroleum Administrator Ickes followed promptly. This generally was taken as a move to strengthen the Civilian Supply sector since the civilian needs cut sharply across the agencies headed by the new board members. While the common assumption may be perfectly true, the move brings into the WPB fold three outside autonomous agencies and gives them a common meeting ground short of the White House which they have not had before. By so doing it removes for the time being the threat of the formation of some overall agency or super war cabinet that might be interposed between the President and the War Production Board.

Civilian Supply is to receive greater attention than in the past. In 1942 emphasis was on immediate increase in production of military items. Today the civilian side is assuming greater importance because a breakdown in the civilian economy would be fatal to the war effort. The meaning of civilian supply is not solely goods sold at retail at the corner store. The term also refers to the production of non-military items purchased by mines, mills and factories in the regular course of their business to be used as operating supplies and for plant maintenance.

Months ago, topside officials of WPB realized that the non-military program had to be planned and scheduled along with the military program in order that the country's war production effort could function with the greatest efficiency. Plans to that end are being carried out.

The stated policy has been to give repair and maintenance high rank in the distribution of materials. Result in the chemical field has been the revision of repair and maintenance orders not only to permit orderly scheduling of production of repair parts and replacement items but also to permit forward planning so that action on the civilian industries is in step with military production and the future military strategy.

While the forward thinking elements of the War Production Board are now considering plans for demobilization and reconversion of industry, high officials of the armed services are issuing warnings that the load is to become heavier instead of lighter. At one of his press conferences, Under Secretary of War Patterson warned, "The idea that equipping the Army is nearing completion is wholly unfounded. The job of furnishing our armed forces with their requirements is a job that will grow until the peace conference."

Careful analysis of these apparently conflicting views shows that the armed services and the War Production Board are closer together in their thinking than they have been for some time. WPB has in mind the necessity of keeping the production lines in a fluid state so that the changing requirements of the military can be reflected in the output of war material with the least delay. This is in addition to the common sense policy of keeping the present facilities in the best operating condition. At the same time if materials and production facilities should become available, as the result of changes in military requirements, WPB will make use of the opportunity to produce additional food, clothing and shelter for the civilian population.

Transfer of Workers

To say that the rules laid down by WMC Commissioner McNutt governing job transfers irk labor is putting it mildly. And there is no question but that the role he must play also irks politically conscious Paul McNutt. The manpower boss took pains to point out that the President's order left him no choice when he issued WMC Regulation No. 4 restricting the transfer of workers. The language of Section 3 of the Executive Order is clear and to the point. It reads: "The chairman of the War Manpower Commission is authorized to forbid the employment by any employer of any new employe or the acceptance of employment by a new employe except as authorized in accordance with regulations which may be issued by the chairman of the War Manpower Commission, with the approval of the economic stabilization director, for the purpose of preventing such employment at a wage or salary higher than that received by such new employe in his last employment unless the change of employment would aid in the effective prosecution of the war."

The new rules permit the movement of workers from non-essential industries to essential industries, but prevent shifts from essential industries to non-essential industries or from essential industries to essential industries for higher wages if the worker has been employed in an essential activity during the preceding 30-day period.

In areas where WMC approved employment stabilization plans are in effect, employers may hire new workers without restriction on wages paid if such hiring is permitted under the program. The 12 Western non-ferrous metal mining states constitute an area where such a program is in effect.

On May 1, there were 67 employment stabilization programs in effect and the War Manpower Commission expected to have every industrialized community covered soon.

Essential Industries

The revised list of essential industries and activities issued simultaneously with WMC Regulation No. 4 touches upon chemical industry activities as follows: Production of Chemical and Allied Products and Essential Derivatives Thereof: Glycerin; turpentine, rosin and other naval stores; wood tars, oils, acids, and alcohols; plasticizers; lubricating oils and grease; animal and vegetable oils; fertilizers; tanning materials; chemical pulp; salt; synthetic rubber; coal-tar products; plastics; compressed and liquefied gases; refined sulphur; acids; caustic and other sodas; alcohols; electro-chemical and electro-metallurgical products such as carbide, sodium and potassium metals and high-percentage ferro-alloys; drugs and medicines; insecticides and related chemical compounds; synthetic textile fibers used in military equipment exclusively; grease and tallow. (Explosives, flares, and other fireworks, generally classified as chemical products, are included with ammunition.)

Production of Rubber Products: All rubber products.

Production of Textiles: Spinning and weaving of fabrics for parachutes and powder bags; of canvas for tents, sails, tarpaulins, and related heavy canvas products; asbestos, fibrous glass, cotton, woolen, knit, linen, silk, and synthetic fiber goods for military and industrial use.

Technical, Scientific, and Management Services: The applying of technical, scientific and management services to establishments engaged in war production; union-management negotiation services; and the publication of technical and scientific books and journals.

Educational Services: Public and private industrial and agricultural vocational training; elementary, secondary, and preparatory schools; junior colleges, colleges, universities, and professional schools, educational and scientific research agencies; and the production of technical and vocational training films.

Smelting, Refining and Rolling of Metal: Primary and secondary smelting and refining, alloying, rolling, and drawing of iron, steel, copper, lead, zinc, magnesium, aluminum, brass, bronze, nickel, tin, cadmium, ferro-alloys, and any other metals used in the production of war materials; and scrap salvage.

Production of Ammunition: The production of bombs, mines, torpedoes, grenades, chemical warfare projectiles, explosives, fuses, pyro-technics, as well as products such as glycerin which go into the manufacture of ammunition.

Director of Geological Survey

Confirmation of the appointment of William Embry Wrather as Director of the Geological Survey marks the first time in the history of that organization the post has not been filled by a man from the ranks. But as Mr. Wrather pointed out, "In the 25 years I have spent as a consulting geologist I have worked constantly with the Geological Survey and we are anything but strangers."

When asked by a *Chem. & Met.* representative about his plans for the future, Mr. Wrather replied, "The Geological Survey is a government organization that is deep in direct war work. That work must be continued at top speed. Changes, if any, will be for the purpose of making the war work of the Survey more effective. The only other thing that I can say at this time is that I shall do my utmost to maintain the scientific integrity of organization."

Mr. Wrather went to his new assignment from the Board of Economic Warfare where he held the position of Associate Chief of the Metals and Minerals Division. His professional work has been largely in the field of petroleum geology but he is recognized for his wide understanding and appreciation of the entire field. His name was proposed by a committee of the National Academy of Sciences as a man of high administrative ability as well as the required technical and scientific competence.

Rubber Versus Gasoline

Perennial argument between the Army and Rubber Czar William Jeffers broke out with renewed fury last month, and got a full airing before the Truman Committee. Attempt of Under-Secretary Patterson to lay the shortage of aviation gasoline on the synthetic rubber program doorstep which most people considered a case of the pot calling the kettle black, precipitated the ruckus. Major complaint of Mr. Patterson was that William Jeffers had grabbed more than his share of the critical components for the construction of synthetic rubber plants which could have better been used for the construction of plants to make hightest gasoline.

Washington officials who are close to the problem have two reactions to the scene put on by Messrs. Patterson and Jeffers. One is that Mr. Patterson is finding Mr. Jeffers to be a very poor selection as goat for Army mistakes. More thoughtful individuals say that while there is some truth in the Army contention that the rubber program has more than its share of critical materials and parts, i.e., the best of the scramble for priorities, they cannot see why the Army has any grounds to gripe. Certainly the Army has been guilty of worse grabs than the rubber program.

General opinion in Washington is that Mr. Patterson could have served the Army better if he had frankly said that estimates of the high octane gasoline requirements had proved to be low in the light of recent experience. A call for help would then have met with instant response from all sides. The lack of candor exhibited in the handling of the complaint caused many to question whether the shortage of aviation gasoline really did exist. Further speculation was whether Mr. Patterson had not swung so far out of line that heads might roll in consequence.

Another Army error in estimating its requirements may ease the high octane gasoline situation. Ammunition production facilities have proved to be greatly in excess of requirements and many plants are being closed. Sharp revision of programs all along the line has been the result and many chemicals that have been none too plentiful are now in relatively easy supply.

Toluene that at one time was in such short supply that the war effort was slowed will be available in such quantity that its equipment may be used in the production of high octane gasoline. There is so much nitrogen production capacity that the ammunition requirements can be met and the farmers given more chemical nitrogen for fertilizer than they can use and plants will still have to be closed down.

Representatives of the cotton seed oil mills were called to Memphis late in April to discuss a new cotton linters program for the coming season. The letter calling the meeting explained that by the end of July a large stockpile of chemical linters would be accumulated and it was desirable to discuss a readjustment of the program, cutting it to fit requirements. No solution was found to the problems brought up at the Memphis meeting and more study will be given to them by the industry.

Alcohol Supply

The cut back of the rate of manufacture of ammunition and explosives also eased the demand for industrial alcohol. This may have resulted in the reports that because of lack of storage facilities alcohol stockpiling program would have to be abandoned for a time at least which would permit the distilleries to resume the production of whiskey.

By mid-April Defense Supplies Corporation had tankage for the storage of approximately 115 million gallons. At the end of April a further announcement was made that storage capacity for 45 million gallons of alcohol was available in addition to the stockpile which at that time amounted to more than 100 million gallons, half of which had accumulated since the first of the year. These figures do not include operational stocks of ordnance or chemical warfare programs nor storage facilities at the butadiene plants.

In addition to the provision of additional storage for 190 proof alcohol, the reduction in the estimated requirements made the construction of new plants unnecessary. Construction of five midwestern plants was held up just six weeks after the selection of the plant sites had been made public. Announcement of the deferment was made to the Senate Agriculture Sub-committee on the Production of Industrial Alcohol from Farm Crops by Dr. Walter G. Whitman, Assistant Director of the Chemical Division and John W. Boyer, Chief of the Alcohol and Solvents Section of the Division.

The Gillette Committee keeps a sharp eye on the alcohol program since it cherishes the idea that a much greater part of the production can be based upon agricultural products than is the case at the present time. Actually no decision has to be made for some time as to whether more plants will be needed or not. The anticipated production of alcohol during the next 20 months is substantially in balance with estimated demands. The reserve stocks in storage not only are a cushion against any sudden demands but are sufficient to allow time for new construction if unforeseen new requirements should develop. The situation can be explained in another way by saying that there is plenty of time to provide production facilities for alcohol to supply a butadiene plant or a smokeless powder plant.

Repair and Maintenance

Latest revision of the chemical industry's repair and maintenance order, P-89, made the last of April, redefines producer to include persons "engaged in the production of chemicals or allied products." This broadens the field of producers covered by the order. Formerly P-89 included only those who had a definite chemical reaction in their process of manufacture. Now products allied to chemical production come within the terms of the order in their PRP applications were processed by the Chemicals Division, or would have been processed by the Chemical Division had they made PRP applications.

Other changes in the order are to bring it into line with CMP policy. Self assigned ratings are limited in amount to $500 for a single fabricated part in place of a limit of $250 previously. The order as revised is independent of CMP Regulations 5 and 5A and provides that producers shall not be given material under those regulations.

This might not hold in the case of producers whose requirements for maintenance, repairs and operating supplies are small in quantity and with individual items running less than $500. Applications for priority assistance under P-89 from these firms may possibly be turned down on the grounds that the materials can be secured under Regulation 5 which requires no reports.

New Products REPORT

New Products Report 5 New Phosphates with Interesting Possibilities

Here are five new phosphates with interesting possibilities as yet unexplored. Four seem to have definite utility in glass, chinaware, porcelains and enamels. One is an excellent source of calcium and phosphorus for mineral enrichment of foods.

While only one of these phosphates is available as yet in commercial quantities the others could be placed in quantity production if sufficient demand develops. For experimental samples, write to: MONSANTO CHEMICAL COMPANY, Phosphate Division, St. Louis, Missouri.

CALCIUM MAGNESIUM PYROPHOSPHATE $Ca_2Mg_2(P_2O_7)_2$

PHYSICAL PROPERTIES:

Molecular Weight: 476.88
Appearance: Grey powder.
Solubility: Insoluble in water. Soluble in acids.
Grade: Technical.

SUGGESTED USES:

In ceramic industry as a constituent of porcelains and enamels.

AVAILABILITY:

Limited quantities available for experimental investigation.

ALUMINUM METAPHOSPHATE $Al(PO_3)_3$

PHYSICAL PROPERTIES:

Molecular Weight: 263.91
Appearance: White crystalline powder.
Melting Point: Above 1700°C.
Solubility: Insoluble in water. Practically insoluble in acids.

SUGGESTED USES:

As a constituent of glasses, chinaware and porcelains.

AVAILABILITY:

Available in limited quantities.

CALCIUM PYROPHOSPHATE $Ca_2P_2O_7$

PHYSICAL PROPERTIES:

Molecular Weight: 254.20
Appearance: White, non-gritty powder.
Odor: None.
Taste: None.
Melting Point: 1230°C.
Density: 36 to 37 lbs. per cu. ft.
Solubility: Insoluble in water. Soluble in acids.

SUGGESTED USES:

As a source of calcium and phosphorus in mineral enrichment of foods.

AVAILABILITY:

Commercially available in 100-lb. kegs and 200-lb. barrels.

BARIUM METAPHOSPHATE BaP_2O_6

PHYSICAL PROPERTIES:

Molecular Weight: 295.40
Appearance: White crystalline powder.
Melting Point: Red heat (about 850°C).
Solubility: Insoluble in water.

SUGGESTED USES:

1. As an opacifying agent in glazes.
2. As a constituent in special types of glass.

AVAILABILITY:

Limited quantities available for experimental investigation.

MAGNESIUM PYROPHOSPHATE $Mg_2P_2O_7$

PHYSICAL PROPERTIES:

Molecular Weight: 222.68
Appearance: White crystalline powder.
Melting Point: 1383°C.
Solubility: Insoluble in water. Soluble in acids.

SUGGESTED USES:

As a constituent of porcelains and enamels.

AVAILABILITY:

Limited quantities available for experimental investigation.

"E" FOR EXCELLENCE—The Army-Navy "E" burgee with two stars, "representing recognition by the Army and the Navy of especially meritorious production of war materials" over a two-year period flies over Monsanto.

MONSANTO CHEMICALS
SERVING INDUSTRY... WHICH SERVES MANKIND

MILITARY REQUIREMENTS FOR GLYCERINE DEMAND HIGH PERCENTAGE OF TOTAL OUTPUT

The War Production Board has issued an over-all report on glycerine, outlining military, naval, and lend-lease uses, civilian requirements, and the present supply situation.

In the Army, glycerine compounds rank second only to alcohol as a solvent in medicinal solutions. In pure form, glycerine is a powerful antiseptic, used in many types of surgical dressings. The highly effective emollient action of the chemical makes it valuable to dentists and physicians in the treatment of teeth and throat disorders, as well as sunburn and other skin irritations.

Aside from its medicinal uses, glycerine finds a spot in a wide variety of indirect military requirements. For example, the dull camouflage coatings on tanks and planes require large quantities of glycerine. Seaplanes covered with glycerine-less coatings are soon stripped clean by the corrosive action of salt water, wind and weather. Even the Army however, has had less glycerine for protective coatings than it really wanted. Glycerine compounds on wooden ammunition boxes are out, and even for Army and lend-lease purposes, beverage caps no longer are processed with glycerine.

Cellophane, an item of military necessity, can be made without glycerine, and 55 percent is. The remaining 45 percent of military cellophane made with glycerine is restricted to those uses where durability is a main factor, or as a packaging agent for food, where the toxic quality of the glycerine substitutes prohibits their use. The most durable cellophane of all goes into capes for army personnel as a protection against possible mustard gas attack.

Glycerine used in glassine and grease-proof papers is restricted entirely to ordnance and food packaging. In the textile and leather fields, where glycerine is vitally necessary to military dyes, as a leather softener, and as an adhesive in the manufacture of shoes, its use has been curtailed as much as possible.

In the Navy, the versatile nature of glycerine makes it irreplacable in gun recoil mechanisms, in hydraulic control mechanisms and other equipment, in ship's steering gears and compasses, and again in the protective coatings for ships' parts and guns.

The vastly increased size of the Army and Navy has resulted in a corresponding increase in military demands for glycerine. These demands had to be met largely through severe civilian curtailment.

More than a year ago, the War Production Board completely prohibited the use of glycerine in the manufacture of anti-freeze solutions, and, at the same time, restricted all manufacturers to 70 percent of their 1940 consumption, unless they were working on medical or military items. With these restrictions, glycerine supplies continued to flow into most civilian items as in the past. Later in 1942 however, a tightening supply situation required additional cuts in civilian consumption. In November, for example, use of glycerine in tobacco was cut to 48 percent of the 1940 usage, in beverages to 50 percent, in cosmetics and toilet preparations to 40 percent.

January, 1943, saw the elimination of glycerine from candy, beverages and gum, its use in tobacco reduced to 35 percent of the 1940 consumption, its use in cosmetics, flavorings and shortening dropped to 25 percent. In March, 1943, glycerine disappeared entirely as in an emulsifying agent in shortenings.

On the first of April, 1943, many more civilian items were added to this list. No more glycerine was allotted to manufacturers of cosmetics, dentifrices, lotions, beverages, flavors, candy and all edible products (with the exception of margarine) chewing gum, shaving cream, tablet and pad adhesives, tobacco, shortening, beverage crown caps, protective coatings for most civilian uses, soaps, hair tonics and shampoos.

The effect of these curtailments has not yet been felt by most consumers, since most retailers still have products containing glycerine on hand. Shortly, however, the "smooth" quality which glycerine imparts to some beverages will be lacking; cigarettes will lose the binding and moistening effect, some civilian enamels will lose that same durability that makes glycerine so valuable for military coatings.

Even though these drastic curtailments have been effective in meeting the needs of the military and lend-lease, recent surveys indicate that essential needs can be met only through continuing supplies of waste fats from the housewives of the country. This situation continues in spite of the fact that cuts in civilian use amount to millions of pounds. For example the tobacco industry, largest peace-time user, was allowed 1,280,000 pounds during the first three months of 1943, as opposed to a peace-time consumption of more than 22,000,000 pounds during 1940, cosmetic uses dropped from 4,760,000 pounds in 1940 to 630,000 for one quarter of 1943 and beverages from 3,225,000 to 24,000 pounds.

Efforts to increase the production of glycerine have met with little success because of raw material shortages.

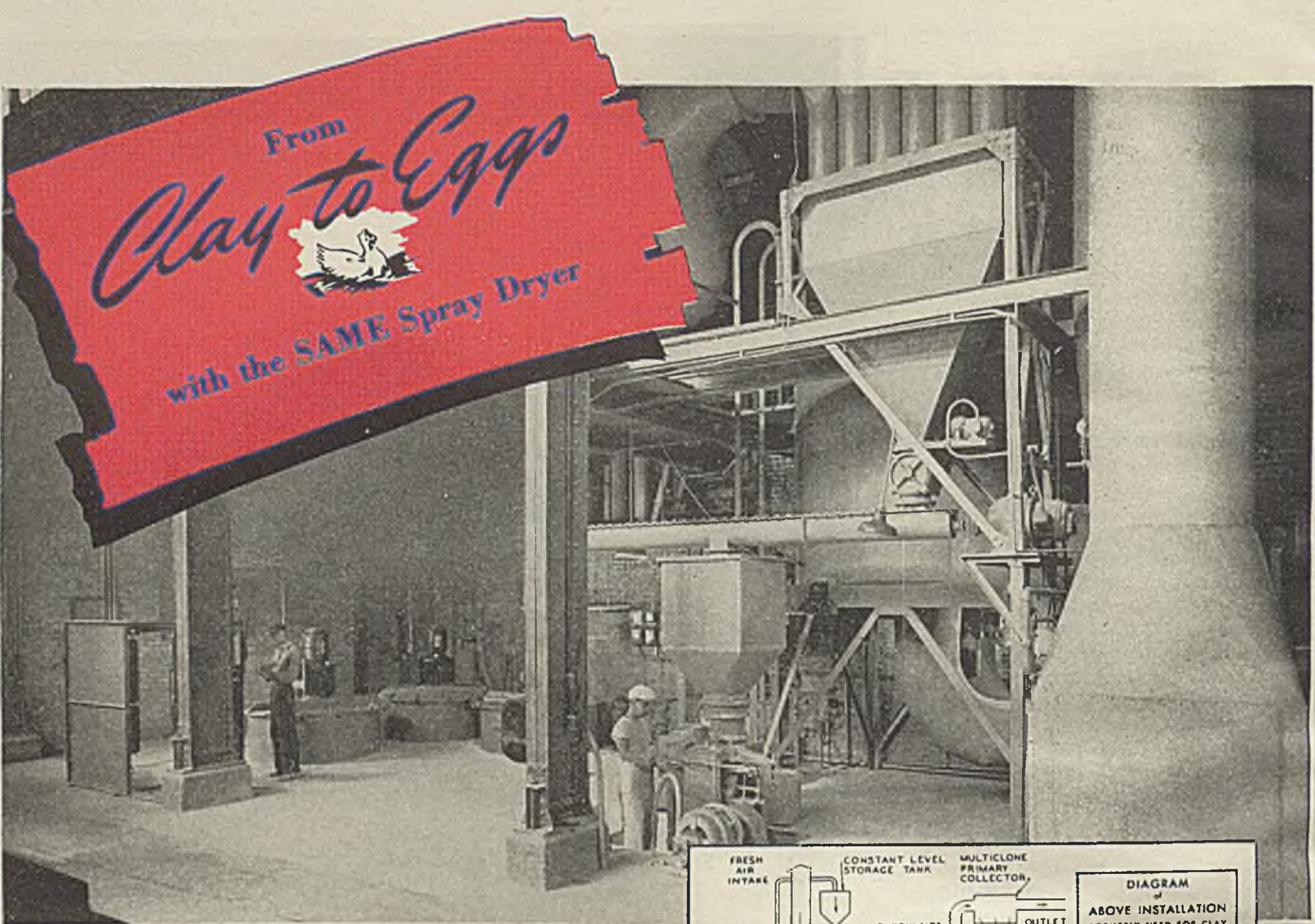
Glycerine is obtainable through three processes: (1) "fat-splitting", a method which produces approximately 10 percent of our present supplies; (2) fermentation of sugar, used by Germany; and, (3) as a byproduct in the manufacture of soap, by far the most productive source.

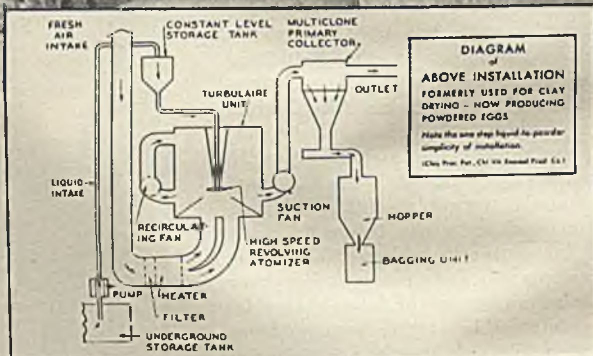
Fat-splitting is a complicated process whereby basic fats are divided into their component parts, one of which is glycerine. In the past, use of this process has been dependent on the industrial demand for the various other components as well as glycerine. The limited nature of this prewar demand discouraged development of production facilities in the days when stainless steel and other metals were plentiful. The currently critical nature of these materials needed for synthetic rubber and aviation gasoline plants and many other war uses makes expansion of fat-splitting facilities impossible at the present time.

Fermentation of beet sugar, followed by chemical distillation, produces glycerine as well as a host of other chemicals. This method is Germany's largest source of glycerine. Other products resulting from this fermentation distillation process go into Germany's synthetic rubber.

Production of glycerine in the soap industry is dependent on the supplies of fats and oils available. In 1941 soap factories used 2,143,000,000 pounds of fats. This year production calls for a maximum use of 1,800,000,000 pounds leaving an annual production capacity of 350,000,000 pounds unused.

Fat and oil shortages appeared early in the war. Most of this country's imports came from the Pacific area, and the annual volume of more than a billion pounds dwindled to almost nothing. The rising tempo of war production drew more and more fats and oils into industrial uses, both as raw materials and as lubricants. For example, every ship launched requires an average of 40,000 pounds of animal tallow to grease the ways. Recently, as war fronts multiplied, vast quantities of fats and oils have been shipped to United Nation troops for use as food, military needs, and other supplies.





Proof of the unusual versatility of *TURBULAIRE EQUIPMENT!*

HERE is the interesting story of a *TURBULAIRE* Spray Dryer installation that was designed for one job, then went to war in an entirely different one...

Shortly before this country entered the present war, an Illinois manufacturer of vitreous enamel products completed the installation of new refining equipment for processing his enamel clays. The heart of this equipment was a TURBULAIRE Spray Dryer in which the clay slip was finely atomized and dried to a powder, then collected and sacked.

This system was highly efficient—so much so, in fact, that it was written up by leading trade journals as a model for others in the field. That was in 1941!

THEN CAME THE WAR  **and almost overnight dried foods became more important than dried clay. So today, this *same TURBULAIRE* installation is doing a war job turning thousands of eggs a day into powder for shipment to our soldiers and allies throughout the world!**

TURBULAIRE SPRAY DRYERS ARE *VERSATILE*, as this installation proves. They will handle most liquids that are pumpable, whether colloidal suspensions, true solutions or slurries. Equally important, *TURBULAIRE* drying action is so fast that any possible harmful heating effects injurious to products sensitive to heat (eggs, for example) can be controlled and minimized. And *TURBULAIRES* are simple—one step from liquid to powder, eliminating filtering, drying, grinding and classifying steps often necessary in other types of equipment.

Send for Dryer Data Sheet to fill out for guiding our engineers in recommending equipment that best meets YOUR requirements!

Write for Turbulaire Bulletin!

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INTERPRETING WASHINGTON

EDITOR'S NOTE: *Copies of the orders, rules and regulations covered in this installment may be obtained by writing to the appropriate federal agency, citing the order number or release date.*

HAND TRUCKS

General Limitation Order L-111, amended by WPB on April 13, places new restrictions on the production of the various kinds of trucks, dollies, trailers, etc., which are used for transporting material in industrial plants, warehouses, railroad depots, docks and for similar purposes. Purchase orders for new equipment or parts may be accepted only if they bear preference ratings of AA-5 or higher. Repair parts are exempted from this provision if certification is made that the parts will be used only for repair purposes. New restrictions have been placed on the use of ball or roller bearings, cast steel wheels, iron and steel, copper and copper base alloys, aluminum, tin, cadmium, zinc, stainless or chrome steel, and metallic plating and finishes. Purchasers desiring these materials must certify why the exceptions are applicable. Exempted from the Order are deliveries of parts processed before April 23, parts or equipment in process of manufacture by April 23 for purchase orders on hand prior to that date, or for the direct use of the armed services until 90 days after the effective date of the Order.

CONSTRUCTION EQUIPMENT

The production and sale of construction machinery, equipment and repair parts were further restricted on April 9 by amending of Limitation Order L-192. Four schedules are set up in which specified items are grouped according to the degree and nature of the limitations and restrictions. In order to encourage full utilization of existing equipment, parts needed for actual or impending breakdowns or for maintenance are obtainable upon certification that they are to be used for this purpose and that the item to be repaired has been registered as required by Limitation Order L-196. In the case of equipment used on "Essential projects," the highest rating carried by the project may be assigned to the purchase order for repair parts. The former restriction of purchase orders for repair parts to 5 percent of the price of the equipment has been revoked.

CONTRACTORS' PUMPS

Limitation Order L-217, schedule VII, was amended by WPB on April 27 to clarify the definition of pumps. "Pumps" means gasoline or electric motor driven pumps, skid or trailer mounted, ordinarily used by contractors for dewatering and supply, such as centrifugal self-priming pumps, diaphragm pumps, triplex piston road pumps, and plunger pumps. This definition does not include Underwriters' approved fire-fighting pumps, farm type pumps or industrial type pumps.

ANTI-FRICTION BEARINGS

General Preference Order E-10 issued April 13 by WPB supplements the General Scheduling Order M-293 with respect to anti-friction bearings. As of June 1, producers must schedule 85 percent of each quarter's bearings to fill purchase orders received for one or more bearings of any one size having a total purchase price of $500 or more, or for more than 500 bearings of any one size. The other 15 percent of the producers' schedule must be devoted to miscellaneous orders not included in these catagories.

PIPE FITTINGS

Gray cast iron, malleable iron and brass and bronze pipe fittings are now administered under Limitation Order L-288 issued April 17 by WPB, instead of under Schedule II of Limitation Order L-42 which has been revoked. The change was necessitated by the recent transfer of supervision of Schedule II from the Plumbing and Heating Division to the Shipbuilding Division. Operations of companies subject to the Order are not affected.

PORTABLE CONVEYORS

General Limitation Order L-287, issued May 3, placed the production and delivery of portable conveyors used to move bulk materials under strict control. "Portable conveyor" means any new conveyor, either wheel or crawler mounted, of the belt, drag, flight, or scraper type, or portable hopper car track unloader, not including underground mining machinery or conveyors used on rails. Delivery can be made only on those orders which bear an AA-5 rating if placed on or after May 10, or an A-1-c rating if placed prior to that date. Purchase orders for the armed forces, or other government agencies specifically named in the Order, are exempted and must be filled.

Restrictions on orders for repair parts do not apply to any order for necessary repair or maintenance parts in an amount not exceeding $300 for any single portable conveyor.

BURLAP BAGS

Conservation Order M-47, amended on April 30, provides a quota for each burlap bag manufacturer on a basis of the quantity of burlap he used in 1939 and 1940. Current restrictions on the weights and widths to be imported are as follows:

36 inch 7½, 10 and 12 oz.
37 inch 10 oz.
40 inch 7½, 8, 10, 10½ and 12 oz.
45 inch 7½ oz.

Up to two-thirds of each importation 40 inch 10 ounce burlap shall be imported in preference to other constructions to the extent that it is available.

STEEL DRUMS

Preference Rating Order P-76, which assigned an A-4 rating to steel drum manufacturers for the procurement of hot rolled sheet steel, was revoked on April 8 by WPB. At the same time, General Preference Order M-45 was amended to eliminate reference to Order P-76. Order P-76 is no longer useful, since manufacturers now apply for an allotment number under the Controlled Materials Plan.

COPPER AND ZINC

Order P-134 was revoked on April 15 by WPB to prevent confusion with CMP regulation No. 5 which went into effect on April 1. The P Order assigned preference ratings to producers of copper, zinc and alloys of those metals for the acquisition of necessary repair and maintenance materials which are now obtainable under CMP No. 5.

EDUCATIONAL LABORATORIES

Preference Rating Order P-135 was amended by WPB on April 20 to permit educational laboratories to purchase their full annual requirements of reagent in any one quarter, thus permitting educational institutions to continue their practice of ordering in one lot. This appears to be economical both in transportation and in manpower since the amount of chemicals involved is not large.

CRITICAL MATERIALS STATUS

Issue No. 8 of the Material Substitutions and Supply List, dated April 15, gives a comprehensive picture of the current status of materials used in war and essential civilian production. Ranked on the basis of necessity and availability, more than 500 materials are arranged in the following three groups:

Group I—Materials which are insufficient in supply either for war demands alone or for war plus essential civilian demands.

Group II—Materials which are sufficient for war and essential civilian production.

Group III—Materials available in sufficient quantity for use as substitutes for the more critical materials in groups I and II.

Present and anticipated trends in production are reflected in the changed

positions of several materials in the new listing. For instance, the mounting importance of the food situation has created a new group of Insecticides and Fungicides, some of which previously had been listed under chemicals or miscellaneous products. Diversion to war production as well as increased food production has made the food oils relatively more critical. Fish and linseed oils, both previously appearing in group III, are now in group II. Of the nonferrous metals, bismuth, cadmium and tin have become relatively more tight. In the ferrous group, the classifications remain about the same.

CMP REGULATIONS NOS. 5 AND 5A

Both of these regulations have been amended to remove from the list of items assigned preference ratings, automotive replacement parts and maintenance equipment, cellophane and similar transparent materials derived from cellulose having a gage of .003 in. and cellulose caps or bands of any gage. The former change places all motor carrier transportation on an equal footing with respect to securing repair parts, and the latter change prevents the use of MRO ratings to secure cellulose caps or bands which are used invariably for packaging.

FORM PD-1A

Business firms and individuals who use this form must use the revised version which was issued January 16, 1943: yellow for products to be exported and white for all others. In addition, these forms should always be filed with the WPB field office nearest the person seeking priority assistance. Otherwise unnecessary delay will be entailed.

GLASS CONTAINERS

Supplementary Order L-103-a, issued April 13 by WPB, was designed to assure an equitable distribution of glass containers, particularly food containers, during the peak canning season this summer by preventing excessive forward buying of glass containers. As of April 18, no commercial user shall accept or contract for any empty new glass container which will increase his inventory thereof to more than two carloads or sixty days' supply. Unless previously revoked this Order shall expire at the close of business on September 30, 1943.

ETHYLENE GLYCOL

Limitation Order L-51 was amended by WPB on April 19 to prohibit the use of anti-freeze containing ethylene glycol for civilian passenger automobiles, including station wagons and taxicabs. The amended Order is effective from April 1, 1943, to March 31, 1944. Other types of anti-freeze are available such as those containing ethyl alcohol, methyl alcohol and isopropyl alcohol. Ethylene glycol may be purchased for use in commercial vehicles and stationary engines if a certificate of authorization is filed with the distributor stating that the product will not be used for passenger automobiles.

SOFTWOOD PLYWOOD

Limitation Order L-150-a was amended on April 10 by WPB to insure that softwood plywood distributors' inventories at all times will be sufficient to care for repair jobs and other essential requirements of the Army and Navy in various sections of the country. Whereas sales previously could be made on orders with a rating of AA-5 or better, sales from distributors' yards to consumers now require a rating of AA-2X or better. This change does not affect transactions between producers and distributors.

ADIPIC ACID AND DERIVATIVES

Conservation Order M-304, issued April 5, placed adipic acid under partial allocation. The Order restricts the use, delivery or acceptance of delivery of adipic acid or its derivatives except for the manufacture of nylon, unless specific authorization is granted by WPB. Such authorization may be obtained by filing application on Form PD-600 in the manner prescribed in the Order.

MARINE PAINTS

Issuance of amendment to Preference Rating Order P-65 by WPB on April 10 assigns preference rating AA-1 to orders for raw materials which are used by paint manufacturers for the production of marine paints needed to meet repair demands on ships of the Army, Navy, Maritime Commission and War Shipping Administration. Previous to this amendment, marine paint manufacturers had preference rating A-3 which was inadequate to obtain supplies under the revised rating structure.

SHELLAC

Allocation Order M-106 was somewhat clarified by an amendment issued on April 6 by WPB. The amended Order defines shellac as including lac processed no further than bleaching with chlorine or cutting with alcohol or other solvents, but not including lac after it has been mixed with a substantial quantity of other materials, or has been incorporated into molding compounds, or has been made an integral part of some article such as electrical equipment or parts. A consumer is redefined as any person who so uses shellac that it ceases to be shellac as so defined in the Order. A person who merely cuts or bleaches shellac, or who uses a molding compound containing shellac is not a consumer. Cut or bleached shellac, including seedlac, in the possession of a person other than bleacher or importer on Feb. 25, 1943, is exempted from authorization requirements. Shellac which was cut or bleached prior to July 31, 1942, or seedlac cut or bleached prior to Feb. 25, 1943, now in the hands of a bleacher or importer, are exempted from this Order except where special directions were given by WPB. The section on applications is amended to provide that a supplier seeking authorization to accept delivery of shellac for inventory shall apply on form PD-617 in the manner prescribed, specifying as end use "to hold intact pending further authorization."

CHEMICAL COTTON PULP

Conservation Order M-157 has been changed to Allocation Order M-157. The amended Order also provides that WPB authorization is not necessary for deliveries by a producer of 200 short tons or less of chemical cotton pulp in any one month (in lots of not more than 50 short tons to any one consumer in any one month). Consumers who formerly were restricted to 500 lb. may now obtain up to 50 short tons in any one month without specific WPB authorization. Producers are required on or before the 15th day of each month to file a report and apply for authorization to make deliveries during the next month, except that no producer is required to file a report for any month in which less than 50 short tons are produced. Consumers who have on hand 100 short tons or more on the first of a month must file a report on form PD-600 on or before the 5th day of that month.

POLYVINYL ACETATE

Supplementary Order M-15-f was amended on April 17 by the Office of Rubber Director to permit the covering of wood shoe heels. It is believed that polyvinyl acetate will be used in place of latex for this operation. The use of polyvinyl acetate will continue to be controlled through allocation procedure.

CASEIN

Allocation control over processed industrial casein was established by WPB through issuance of General Preference Order M-307 issued April 15 and effective May 1. The Order defines casein as the protein components of skimmed milk which have been precipitated by the action of rennet, acid or sweet or sour whey and which have been washed, dried and ground. Application for authorization to receive or deliver casein may be made on the usual Forms PD-600 and PD-601.

ROTENONE INSECTICIDES

Minor changes in provision for packaging of rotenone insecticides were made by WPB through issuance on April 17 of an amendment to Conservation Order M-133. The amended Order provides that WPB may at any time issue directives to processors concerning the package size for rotenone insecticides. It also exempts from the various restrictions on delivery any rotenone insecticides packaged in quantities of one pound or less in solid form, or one pint or less in liquid form.

COPPER CHEMICALS

General Preference Order M-227 was amended on April 6 to specifically restrict the use of copper chemicals for plating in every case where the use of copper products or copper base alloy products in plating is prohibited under Conservation Order M-9-c governing copper. Copper chemicals means copper sulphate, copper carbonate, copper oxide, copper nitrate, copper chloride, and copper cyanide. The term includes copper chemicals in both cupric and cuprous forms.

PYRETHRUM INSECTICIDES

Control of pyrethrum insecticides allocated to agriculture by the War Production Board was given to the War Food Administrator through issuance by WPB of directive 15 on April 26. The directive gives authority to the War Food Administrator with respect to the sale or other disposition of pyrethrum insecticides to ultimate agricultural consumers and the use of pyrethrum insecticides in agriculture by such consumer. It does not authorize the War Food Administrator to determine the amount of government requirements for pyrethrum or pyrethrum insecticides, to regulate manufacture or import of pyrethrum insecticides, to regulate non-agricultural use or sale of pyrethrum insecticides, or to regulate the sale or other distribution of pyrethrum.

FERROCHROMIUM

Order M-18-a issued by WPB requires each producer of ferrochromium to use, in the production of high-carbon ferrochromium, chrome ores having a weighted chromium-to-iron ratio not exceeding 2.6 to 1. The direction to producers is flexible in that a higher ratio may be used for a portion of production if the average consumption of chromium for monthly production of ferrochromium does not exceed the 2.6 to 1 basis. Producers unable to comply with the terms of the direction may apply for relief to the Chromium Section, Ferro-Alloys Branch.

POLYSTYRENE

Supplementary Order M-170-a, issued April 5, and effective May 1, places polystyrene, a thermoplastic used for high frequency installations in military, aircraft and communications equipment, under allocation. Up to 50 lb. of polystyrene in the aggregate in any calendar month may be received without specific authorization. Producers or distributors must, however, obtain specific authorization for the aggregate of these small orders.

Polystyrene is defined in the Order as polymers of styrene (vinyl benzene), but does not include the copolymers of sytrene with other monomers such as butadiene or methyl methacrylate. Also exempt from the Order are fabricated forms of polystyrene or polystyrene scrap or reprocessed scrap.

MAXIMUM PRICE REGULATIONS

MPR-28, amendment No. 2, issued April 13 by OPA requires converted beverage distilleries producing industrial ethyl alcohol for sale to the government to make their computations of costs and prices on the basis of 190 proof alcohol. A proportionate increase in the price for ethyl alcohol higher than 190 proof is allowed and a proportionate decrease in the maximum price for ethyl alcohol of 188 proof and higher but less than 190 proof is to be made.

Revised MPR-192, issued April 22 by OPA, brings imported finished tar acids, including ortho-cresols and meta-cresols, under the specific regulations controlling prices of imported cresylic acid. Although present importers' maximum prices for duty-free cresylic acid are retailed by the action, OPA placed a total mark-up provision over reseller prices to tighten control over prices at the distribution level. Through this action, persons engaged in purchasing cresylic acid from importers and industrial consumers have been redefined as "resellers" instead of "persons other than importers" and are allowed to add no more than five cents a gallon to the importer's ceiling. As long as present methods of importing cresylic continues, the price for duty-free cresylic to American users will remain the same. Importers are allowed, as under the provisions of the original regulation, to add to the British ceiling price for the appropriate grade of cresylic, in no case more than 72.8 cents per gallon plus specified importing costs which, with a 10 cents per gallon maximum mark-up, brings the price to about 40 percent over domestic cresylic prices.

MPR-298, amendment No. 1, issued April 27 by OPA, provides a formula by means of which manufacturers may figure maximum prices for a new type of dust base made from rotenone, an important agricultural insecticide. The amendment establishes the price ceiling for a dust base made from ground resin by valuing the rotenone contained in the dust base at $13.00 per pound and by adding the delivered cost of the diluent and three cents per pound of the dust base. The new dust is expected to cost more than similar dusts because resin is an expensive form of rotenone, but the greater efficiency of the new dust will offset part of this difference.

Revised MPR-315, issued March 31 by OPA, provides nation-wide specific dollars-and-cents maximum prices for manufacturers' sales of arsenicals other than lead arsenate. The new distributors' maximums were determined by adding normal 1942 margins to the manufacturers' maximum prices on sales to them. Average prices to consumers will remain unchanged, but hereafter all manufacturers' ceilings will be uniform.

MPR-323, amendment No. 2, issued April 22 by OPA, gives sellers of special asphalt products additional methods by which they may establish their own ceilings, and in these and other cases they are not required to submit any report to OPA. If they so desire, they may continue to price under the original method which was established in regulation 323.

Two classes of special products are created.

1. If a product has the same specifications as a standard product but is in the category of a special product because it is sold to a different class of industry, a seller may establish his maximum price by taking the highest price charged to the same class of purchaser during the period August 1 to November 1, 1941, provided that the price charged under a contract entered into prior to this base period need not be considered if the price did not reflect

the current market during that period.

2. If a special product is different in specification from a standard product, the seller may establish his maximum price by (1) the highest price charged during the base period to a purchaser of the same class, provided that the price charged under a contract entered into prior to the base period need not be considered if the price did not reflect the current market during this period, or (2) the maximum bulk price of that standard product having specifications nearest those of the special product now to be priced. If (1) is inapplicable, he may use either (2) or establish a tentative maximum price.

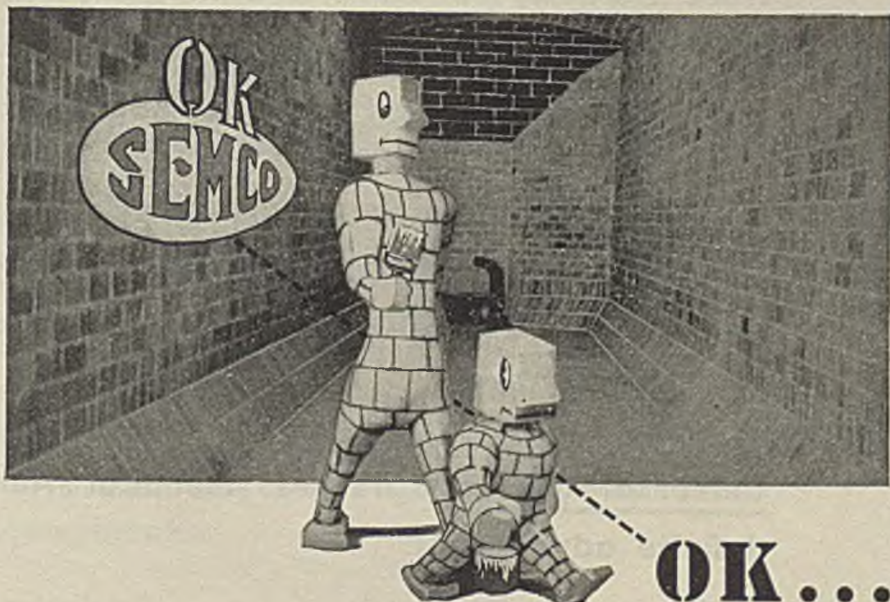
REVISED PRICE SCHEDULES

RPS-17, amendment No. 3, was issued on April 10 by OPA providing greater facility for producers in pricing tin anodes. Maximum prices for the anodes are the highest price charged by the seller for the same type of anode in a delivery made during March, 1942, to a purchaser of the same class or, if no delivery was made in that month, the highest price at which it was offered for delivery in March, 1942. Those who cannot determine a price in this way must calculate a price as far as possible by the same method used in determining prices for a similar anode in March, 1942, and submit it to OPA for approval. Only a small volume of tin is involved in this action as the bulk of tin anodes are made by companies for electroplating their own product.

RPS-43, amendment No. 3, issued April 10 by OPA, makes it clear that the maximum prices for used steel containers apply to sales by emptiers to any purchaser. By removing the qualification that the emptied containers are priced as sold to a filler, operation of the schedule is extended to cover purchases by any buyer. Thus, those who buy the containers for reconditioning may obtain them at or below ceiling prices.

RPS-53, amendment No. 29, issued April 6 by OPA, allows sellers of tallows and greases to add premiums of ⅜ cents a pound when returnable drums, barrels or pierces are shipped in carload lots; ⅞ cents a pound when such containers are shipped in less than carload lots. On non-returnable drums, these premiums are 1 cent and 1½ cents. The purpose of this amendment is to assure a supply of tallows and greases for war industries which now are experiencing difficulty in obtaining them.

RPS-88, amendment 91, issued April 10 by OPA, provides that sellers must allow discounts no less favorable than those allowed pursuant to and stated in contracts or invoices during the 60 days prior to the base pricing date, October 15, 1941. Discounts, however, do not apply to specific dollars and cents prices established by the schedule as the latter are net prices and discounts are not required under OPA regulations. The base period is changed from Oct. 1-15, 1941, to 60 days prior to Oct. 15 in order to include a sufficient number of transactions.



Interesting Compounds

that can be supplied now in limited commercial quantities

TETRAETHANOLAMMONIUM HYDROXIDE
$N(C_2H_4OH)_4OH$

. . . as commercially supplied, is a 40 to 41 per cent solution of the hydroxide in water and methanol. It is a strong base approaching the fixed alkalies in alkalinity. Although its water solutions are stable at ordinary temperatures, they decompose on heating to form weakly basic polyethanolamines. Thus it has value where it is desirable to destroy a strong base that has been useful at lower temperatures. It is an excellent solvent for certain types of dyes, but is not a solvent for cellulose.

DIETHYL "CELLOSOLVE"
$C_2H_5OCH_2CH_2OC_2H_5$

. . . is a colorless medium-boiling (121.4°C.) liquid with a slight ethereal odor. Since it dissolves both oils and water, it is an excellent mutual solvent. It is a solvent for nitrocellulose, and this solubility is increased by the presence of alcohol. In colloidal systems, such as detergents or wetting agents of limited water solubility, it permits dilution with water with less tendency to gel or cloud. A stable compound, it may be used as an inert reaction medium.

METHYLDIETHANOLAMINE
$CH_3N(C_2H_4OH)_2$

. . . is an amine-odored, colorless liquid, miscible with water and benzene. It is suggested as an intermediate in the manufacture of textile auxiliaries, insecticides, emulsifying agents, and corrosion inhibitors. It shows some evidence of selective action in the absorption of acidic gases. Its physical properties include boiling point (at 4mm.), 121°C. and equivalent weight, 119.

The booklet "Chemicals Available in Research Quantities" describes more than 30 new chemicals now available for research study. Write for a copy.

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PRODUCERS OF SYNTHETIC ORGANIC CHEMICALS

FROM THE LOG OF EXPERIENCE

Dan Gutleben, Engineer

A SHREWD GROCER in Beaver, a village of hinterland Pennsylvania, was disturbed when his inventory as of April, 1923 revealed an unhealthy surplus of sugar. He remembered the psychological effect of inflated prices at the end of World War I. Accordingly, he dressed his show window with a special display of sugar and marked the price 30 cents per pound. The ill-informed householders promptly stampeded the store and proceeded to hoard a product which everywhere was a drug on the market. Sugar can do queer hurdles, as in the case of the 6,000-ton cargo of sugar which left Java for Philadelphia on Aug. 1, 1911. When it arrived on October 12 its value was $107,000 greater than at its departure.

THE STANDARD SIZE MANHOLE for pressure vessels is 12 x 16, and it is amazing how easily a 250-lb. boiler-maker can worm his way through. The boiler drums are provided with one manhole at each end and, when men are working within, one hole is provided with a fresh air blower having a capacity of 3,000 cfm. The 1939 log of the annual boiler overhaul credits Providence with the saving of six men, but actually the presence of the two manholes and the fresh air blower is entitled to the credit. To wit:—

The interior surfaces of the boiler drums and tubes are painted annually with a protecting coating which, according to the label on the can, is inflammable. On an occasion while painting was in progress in one of the drums, a welder in an upper drum dropped some sparks through the tubes connecting with the drum below. There were six painters in this drum. The spark confirmed the warning on the can with a lightning flash. By the grace of Providence we saved the men, but lost six pairs of pants!

THE LOWLY MANHOLE sometimes performs heroic service. Its location deserves some consideration beyond the adventitious tag of the draftsman's pencil. Every tank in our House is provided with two 24-in. manholes, one of which is located in the side about 2 ft. from the bottom, and the other, which may be a hinged trap door, installed in the cover.

One Monday morning, right after the House got started, there was a terrific water-hammering in a flash tank. This tank received the condensate from the pans, evaporators, and many other heating surfaces. To remove the cause of the disturbance it was necessary to shut down the plant and send two men into the tank with an acetylene torch. Meanwhile, since steam can sniff out life like a "stab in the back," men were stationed throughout the plant at every valve which could admit steam to the tanks. The work within progressed to completion in a quarter hour's time. Just as the men were about to gather up their tools, someone, somewhere, opened an unguarded valve! The chronicler, standing at the manhole, saw the steam coming and hollered. Out came the men headfirst just ahead of the grim reaper! The tools are still in the tank.

DURING THE LATE WORLD WAR, Doc was employed in a Niagara Falls chemical plant where a chlorinated product was made. At one point in the process, vigorous agitation was required and this was accomplished in twelve spherical-bottom pots by means of high-speed mixers eccentrically disposed so as to produce a vortex in the liquid. A cash prize was set up to enhance production and was paid weekly to the shift that excelled in output. After some see-sawing, the prize went to the big Swede and his midnight shift with such regularity as to excite jealousy and suspicion among the competitors. Doc succeeded in extracting the formula, but, unfortunately, at the price of secrecy.

It happened one night that one of the pots completed its cycle ahead of the rest. The Swede was flabbergasted! He found that one of the mixer paddles had dropped to the bottom and thereby produced a convulsive circulation that increased the effectiveness of chlorine absorption. He checked his conclusions by placing the loose paddle into another pot. Thereafter, he and his men cashed in weekly on their secret. They provided themselves with twelve spare paddles which they suspended in the pots on a crude wire hook. This ceremony took place at the beginning of the shift as soon as the previous shift had gotten safely out of the way. At the end of the day the paddles were returned to their place on the shelf where they were beyond suspicion.

IN '32, THE FOURTEEN good old orthodox 500-hp. boilers which had for many years been contentedly furnishing steam at 150 lb. pressure were thrown out of the window. They were replaced by two $260,000 monstrosities that deliver 8,000 hp. each at 400 lb. pressure. These had to be installed into a constricted place "with a shoe horn." The design was afflicted with a space for each boiler 18 ft. by 48 ft. as to plan, and without limit as to height. This required some radical departures from the conventional and provided problems in the preliminary operation. The old operators were transferred to the new job and the process of unlearning the old procedure and applying the new was accompanied by excitement and hair-raising experiences. Now and then a tube blew out or the feed pump turbine kicked out. The water supply in a modern boiler is good for five minutes and then—disaster!—unless waterflow is returned or the fire turned off. The raw operators were tense and ill at ease. They watched the instrument board like cats watch a rat hole. One Sunday the boilers were shut down and operator Bill Powers took advantage of this circumstance to attend early Mass. He kept a sharp eye on the Father, but his mind was on the feed pump. Suddenly some dozing parishioner dropped a hymn book! Bill reflexively raised up from his bench and was about to beat it to the basement to start the spare pump when consciousness (and embarrassment) returned.

THE OPERATION of the old boilers required little formality. Twice a year each boiler was cleaned and inspected. On one occasion Jimmy Meighn had been inside one of the drums with a scraper. He was one of those fellows who could fall asleep any time or place without notice. The other men were disporting themselves elsewhere, and when the job was judged complete they closed the manholes on the drum and started the feed pump. Not till then did Tom count noses and lo, Jimmy was missing! Diligent search was made but he was nowhere to be found. Tom was about to order the boiler to be drained and opened when one of the boys located Jimmy sound asleep on top of dark boiler No. 1 at the west end.

"US SURVEYORS" on a Union Pacific locating party in Wyoming went through a cold winter in '99. and the camp was occasionally snowed in on Sunday. One of the boys remembered his freshmen physics. On a sheep-herder's trail he picked up one of those old style flat whiskey flasks, filled it with water within an inch of the top, and floated on the surface an inverted homeopathic pill vial having a bubble of air trapped within just large enough to make it float. The flask was fitted with a cork in which a tube was inserted, and the device was then passed around among the blowhards to test their lungs. Pressure on the surface within the flask would reduce the size of the bubble in the vial and presto, the vial would sink to the bottom to proclaim the power of the operator's lungs. However, the tube was plugged under the cork so that no amount of blowing could affect the pressure within the flask. The hokus pokus by which the vial was depressed was a great show of puffed cheeks and a slight pressure of the fingers against the flat walls of the flask. The big giant of a chainman, uninformed of the technique, blew till he was red in the face and then gave up in chagrin.

JOE ECKERT WROTE discouragingly about his loss of trained men to the war effort which now makes a severe burden on every industrial plant manager. I could think of no better words of cheer than an agricultural story contributed years ago by one of Doc's farm journals. A farmer was informed that the cloudburst had flooded out his crops. He knit his brows and became greatly disturbed. Then he asked about neighbor Brown's crop. It had likewise been ruined and, furthermore, neighbor Jones' and all the rest suffered similarly. The farmer brightened up and said, "Well, it isn't so bad after all!"

THE SCHILDBURGHERS of two centuries ago were the symbol of the ultimate in stupidity, and yet on one occasion a natural accident betokened mental receptivity equal to that of Sir Isaac Newton himself. The villagers had planned the construction of a community building, and in fulfillment of this plan they proceeded to log off the timbers from the top of the mountain under which their village nestled. They carried each log laboriously down to the building site. When the job was nearly completed one of the numbskulls stumbled and his log rolled to the foot of the slope. This led to a great discovery. Forthwith the Schildburghers carried all of the logs back to the top of the mountain and let gravity do the work!

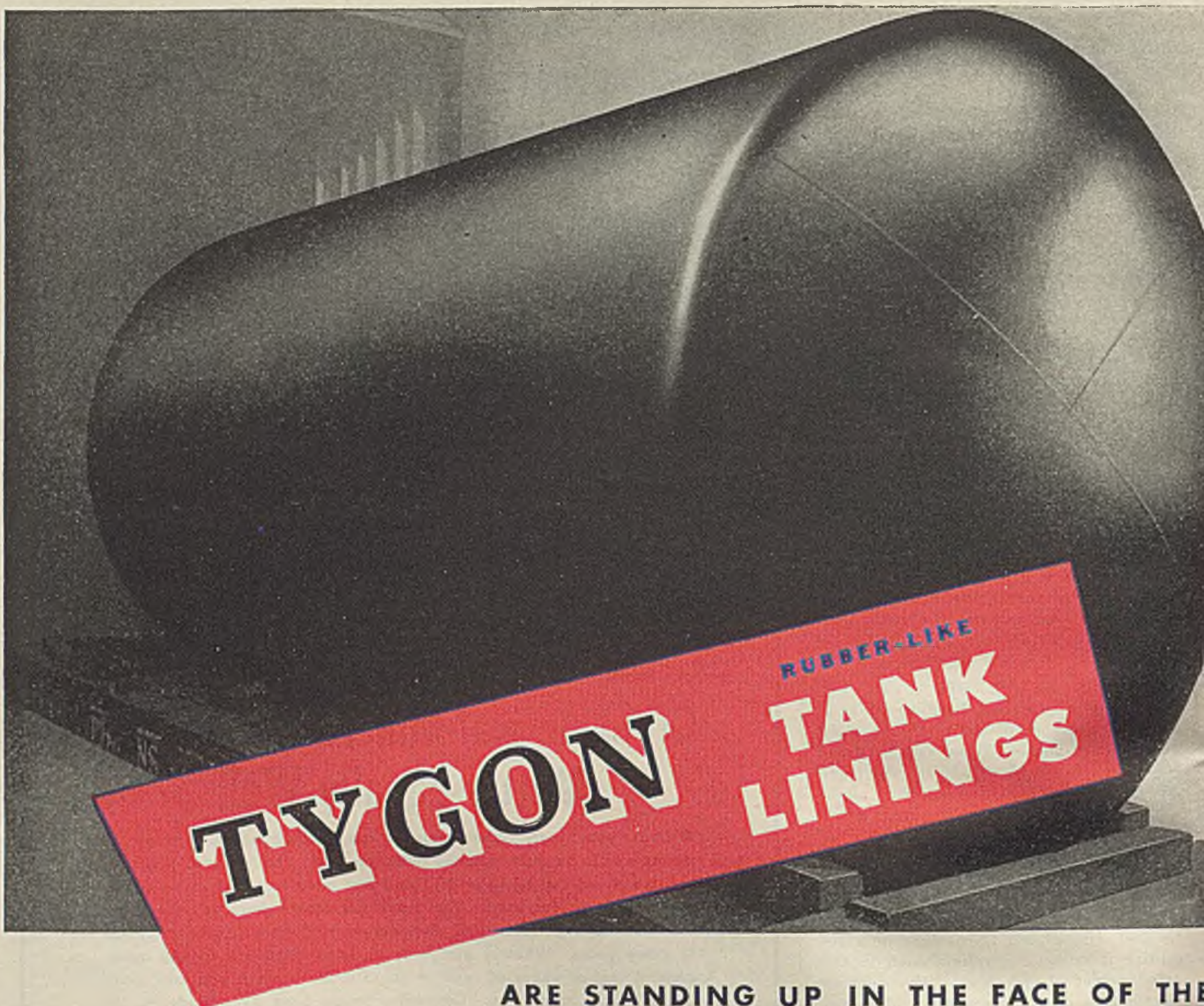
A YEAR AGO KEN MESEROLE, Chief Engineer of the Western Refinery, stopped in at Philadelphia to pay his respects. Through some mental aberration of an operator, the low-pressure end of one of his turbines was disrupted. The circumstances that contributed to the failure were the temporary removal of the relief valve for repair, the closing of the exhaust and drain valve, and a leaky throttle. It was a catastrophe! The builders could not promise a new casting for the duration. Their records showed that a duplicate of this turbine had been built for the Gillette Razor Co. in Boston. Ken immediately got on the telephone and by great good luck learned that the turbine was idle and for sale. In a few days he had it loaded onto the "Speedwitch" headed westward.

THE FARMERS IN more-or-less arid Nebraska, before the New Deal brought the rivers down from the hinterland, put great faith in the efficacy of the willow divining rod as an instrument for determining the location of the family well. The Chronicler, as a small lad, trudged along behind old man Hoffman intently holding a forked twig with apex upward. When the old man crossed the preferred spot where it was hoped that the new water supply could be located, the fork of his twig irresistibly turned down—but mine disappointingly remained up. The performance was repeated for verification and then excavation got under way, accompanied by shoring with willow timber. Sure enough, at a depth of 30 ft. there was the cool and sparkling water that the twig had predetermined! Verily, faith is a wondrous thing.

THE PATH TO TONY'S door in the modest Kensington section is not well beaten, i. e., not yet! Tony is the man of all work attached to the machine shop, and by avocation he is the official rat catcher. He builds an inviting style of rat trap. It consists of a wooden tunnel 6 in. square by 18 in. long, and each end is fitted with a vertical trap door. The bait is supported on the trigger installed at the mid-point of the tunnel so that a tickling by the rat's whiskers drops both doors simultaneously. Tony claims that the merit of his design lies in giving the rat a feeling of security by furnishing a clear view through the box, and yet the walls and deck afford inviting privacy.

SPIRITUALISM ESTABLISHED a strong community of interest between Marion and Jim, attaches of the midnight shift in the boiler house. Many and mysterious problems were solved by spiritual communion during the spooky vigils after low twelve. One morning, after Marion had laid aside his overalls, he missed a $20 bill and became greatly disturbed by suspicion of Shorty. He was certain in his mind of Shorty's guilt, but sought spiritual verification. He and Jim placed themselves in a receptive mood on the relief bench in the amen corner of the room. Jim went to sleep and a dream revealed to him that a dark complexioned young man was loitering about the clothes rack. In the twilight he was unable to identify the features with certainty, but the silhouette was Shorty's. The twain were satisfied. Some time later Marion's gaze fell upon the brick wall that used to cut the old powerhouse into two rooms, and lo! there in a niche was Marion's double eagle. He was unable to determine whether it got there by spiritual or human agency, but he continued to retain his suspicion.

GUARDING AGAINST safety hazards is a function of the engineer. Recently an accident record was presented on the engineer's desk for initialing. There was reported a "cephalic contusion" suffered by John Stupedo, resulting from an encounter with Stephano Sparo in which Stephano employed an oil can as a weapon of offense. The oil can was not seriously damaged, but John was sent to St. Mary's for repair of the scalp. The surgeon's bill was $21.50, and this was assessed against John. The State Labor Board ruling makes an "accident" of this sort compensable only if one of the combatants is a foreman and if it results from an altercation in respect to the performance of the work.

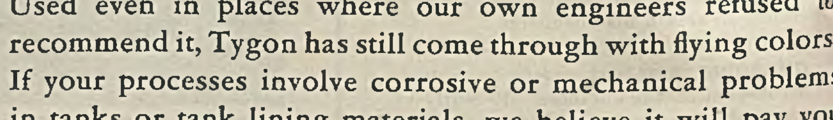


ARE STANDING UP IN THE FACE OF THE TOUGHEST *Triple-Shift* WAR PRODUCTION!

IN hundreds of plants all over America, Tygon tank linings are meeting service demands far beyond what we or the user ever contemplated. Tygon tank linings are standing up to actual operating conditions just as tough as the accelerated tests our laboratories use to determine Tygon's ultimate limits. Used even in places where our own engineers refused to recommend it, Tygon has still come through with flying colors. If your processes involve corrosive or mechanical problems in tanks or tank lining materials, we believe it will pay you to investigate Tygon carefully.

WHAT ARE THE TYGONS?

The Tygons are synthetic materials, resembling rubber in many physical properties. They are characterized by a remarkable resistance to chemical attack, and by wide flexibility in their range of application. The Tygons are made in flexible, semi-rigid, or rigid sheets; in the form of molded or extruded parts, tubes and rods; and are placed into solution for use as a corrosion-resistant paint or for impregnation of porous materials.



PERSONALITIES

Willard Henry Dow

Granville M. Read

✦ WILLARD H. DOW, president of the Dow Chemical Co. was presented the Chandler Medal for 1943 by Columbia University on May 20. The citation accompanying the award named Dr. Dow as "one of the outstanding industrialists of the present generation" and noted as particularly spectacular "the achievements of the company in producing bromine and magnesium from sea water and of synthetic plastics and rubber."

✦ HORACE F. TAYLOR has been appointed manager of Swift & Co.'s soap factory at Cambridge, Mass. He has a service record of 42 years with Swift where he started in the research laboratory at Chicago. For a number of years he was superintendent of the soap factory in that city. Later he took on new responsibilities as technical representative of Swift Industrial Soap and Detergent Division. He succeeds R. H. Hull, retired, in charge of the company's plant.

✦ EDWARD A. BEIDLER, chemical engineer, has been appointed to the research staff of Battelle Memorial Institute, Columbus, Ohio, and assigned to its division of non-ferrous metallurgy. Mr. Beidler is a graduate of Ohio State University from which school he holds bachelor of chemical engineering and master of science degrees.

✦ G. DONALD SPACKMAN has been elected vice president in charge of operations of Lukens Steel Co.

✦ FRANK J. DE REWAL, former research chemist for the Foote Mineral Co., Philadelphia, Pa. has been appointed to the research staff of Battelle Memorial Institute, Columbus.

✦ NATHANIEL ABBITER, former research assistant at Columbia University has been appointed to the staff of Battelle Memorial Institute, and is in the division of mineral dressing and materials beneficiation research.

✦ GRANVILLE M. READ has been appointed assistant chief engineer of E. I. du Pont de Nemours & Co. Mr. Read attended Virginia Polytechnic Institute and joined the du Pont company on Sept. 28, 1915. For approximately the past two and one-half years he has been manager of the war construction division of the engineering department. He succeeds R. D. Moore, who has been commissioned a lieutenant commander in the United States Naval Reserve and is now stationed at Norfolk, Va.

✦ KAM N. KATHJU, research and consulting chemist on the staffs of automotive and paint manufacturers for a period of 20 years, has been appointed technical director of Arco Co., Cleveland, manufacturers of infra-red reflecting camouflage paints.

✦ M. J. CREIGHTON, who has been general manager of cellulose products department of Atlas Powder Co. for the past eight years, has been appointed general manager of the company's industrial chemical department, including the polyalcohols division and the Darco Corp. He will also have charge of research and development including postwar planning.

✦ E. H. BUCY becomes assistant general manager of the cellulose products department, Atlas Powder Co., Wilmington, Del. He resigned from his position as chief of protective coatings section of the chemicals section, W.P.B.

✦ ORVILLE T. BARNETT, engineer of tests for Murex arc-welding electrodes of Metal & Thermit Corp., New York, has been made production engineer for both arc-welding and Thermit welding divisions. Mr. Barnett is a graduate of the Illinois Institute of Technology.

✦ L. S. PALMER, professor of agricultural biochemistry at the University of Minnesota was named chief in the Division of Agricultural Biochemistry by the Board of Regents of the University on March 1.

✦ CHARLES R. DORSETT has joined the staff of the research laboratory of Wishnick-Tumpeer, Inc., as chief paint chemist. He comes to Wishnick-Tumpeer from the technical service department of Alkydol Laboratories.

✦ PHILLIP M. ROBINSON has resigned as assistant director of refining in the Petroleum Administration for War. Mr. Robinson has resigned because of his health.

✦ ERNEST STOSSEL has joined Warwick Chemical Co., West Warwick, R. I. and Rock Hill, S. C. He is in charge of the program for the manufacture of synthetic waxes.

✦ R. H. LEACH, manager of research and development, and vice-president of Handy and Harman, New York, N. Y., has received the Franklin Institute's coveted George R. Weatherill Medal for his extensive work in the development of silver alloys for brazing purposes, with particular reference to the development of two highly efficient low-temperature brazing alloys.

✦ SAMUEL C. PRESCOTT, Emeritus Dean of Science, Massachusetts Institute of Technology, has received the Nicholas Appert Medal of the Chicago Section, Institute of Food Technologists. Eligibility for the award is based on preeminence in the field of food technology and on contributions to the progressive development of food manufacture and processing. Since his retirement last June as dean of science at M.I.T., Dr. Prescott has again been called into consulting service by the dehydration committee of the U. S. Department of Agriculture and by the Research Laboratories of the National Canners Association. At the present he is vigorously active in that work. As dean of science at M.I.T., Dr. Prescott fathered the International Food Technology Conference at Cambridge, Mass., September, 1937, and again in June, 1939, which resulted in the founding of the Institute of Food Technologists at its close.

✦ JOSEPH P. SULLIVAN of Grasselli Chemical Department, E. I. du Pont de Nemours & Co., has been elected president of the Chicago Drug & Chemical Association. Other officers elected were: vice-president, F. Dean Hildebrandt, Prior Chemical Corp.; treasurer, Edgar E. Brand, L. Sonneborn Sons, Inc.; secretary, Gerald F. Pauley, Monsanto Chemical Co.

✦ C. E. BALES, vice-president of The Ironton Fire Brick Co., was elected president of the American Ceramic Society at the forty-fifth annual meeting held in Pittsburgh, April 19. He served as president of the Ohio Ceramic Industries Association during the past two years, and is a director of the American Refractories Institute.

✦ Robert V. Yohe, technical superintendent of the Chemical Division, the B. F. Goodrich Co., Akron, Ohio, has been named plant manager of the government's synthetic rubber plant operated by Goodrich in Kentucky. Dr. Yohe, in the rubber industry since 1931, joined B. F. Goodrich as a research chemist and has held a number of important research and production positions in various divisions of the company. He succeeds J. W. Frasche, who has been named plant manager at another government synthetic plant in Texas, which will also be operated by Goodrich.

S. C. Ogburn, Jr.

✦ S. C. Ogburn, Jr., formerly acting research manager and technical supervisor in charge of new product development, General Chemical Co., has accepted a position with the Pennsylvania Salt Mfg. Co. as manager of the research and development department. Prior to his association with General Chemical Co. in 1937 where he served as Washington representative of the technical department for the past year, Dr. Ogburn was professor and head of the chemical engineering department, Bucknell University. He is a graduate of the chemical department of Washington and Lee University.

✦ Thomas H. Chilton received the award of the 1943 Eggleston Medal of Columbian Engineering Schools' Alumni Association. Mr. Chilton, director of the technical division of the Engineering Department, E. I. du Pont de Nemours & Co., was cited for discovery of principles underlying unit operations of chemical engineering and their application.

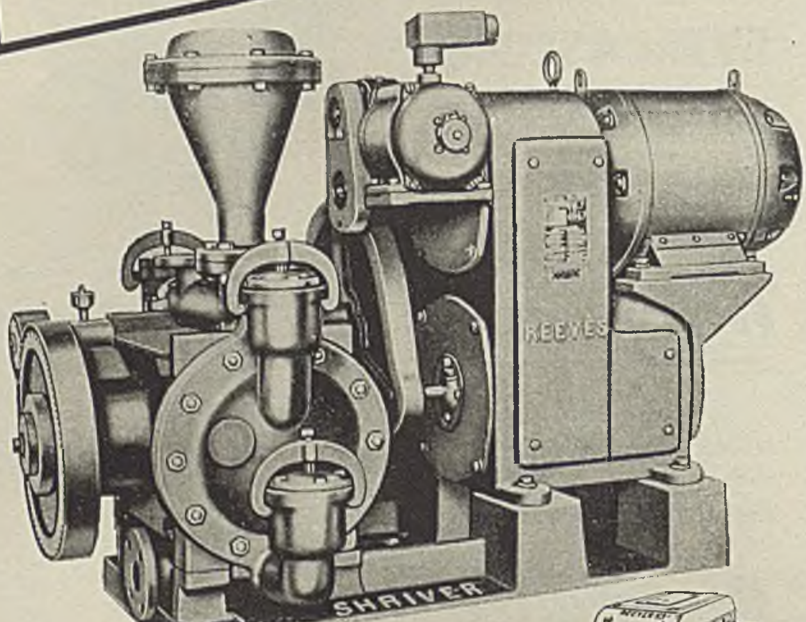
✦ Oliver B. Hayes, formerly employed in chemical engineering for General Chemical Co., Marcus Hook, Pa., has joined the research staff of Commercial Solvents Corp., Terre Haute, Ind. Other additions to the staff are, Earl H. Addison, a Northwestern University graduate, and formerly employed on protective coating work with the lacquer division of Sherwin-Williams, Chicago, Ill., for the past ten years. James R. McClintick, a chemical engineering graduate from the University of Minnesota, who was formerly connected with Swift & Co., St. Paul, Minn., has also become associated with the Commercial Solvents staff.

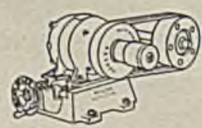
✦ RALPH M. FISCHER and R. C. MORRISON have been appointed to Calco Chemical Division, American Cyanamid Co., Bound Brook, N. J. These two will be associated with the work on synthetic resin textile finishes. Mr. Fischer has been a member of the sales and technical staff of Calco since joining the company in 1940. A bachelor of science in chemistry from Dartmouth University, he has been active in textile dyeing and finishing since his graduation in 1913. He was first identified with Weidmann Silk Dyeing Co., Paterson, N. J. Later he was with Independent Silk Dyeing Co. and United Piece Dye Works. Mr. Morrison joined Calco in 1939, coming from the printing laboratory of Amalgamated Chemical Co. Upon graduating from Lowell Textile Institute he entered the Silver Spring branch of the U. S. Finishing Co.

✦ SIDNEY EISENBERGER has been appointed plant manager and Dr. Robert Rosenthal chief chemist of the Lamon Chemical Corp., New York, N. Y. Both men were formerly associated with Academy Laboratories, Inc., in similar capacities. They will supervise an expansion program and the construction of a new plant.

✦ LEROY L. WYMAN, metallurgist for some 19 years with the General Electric Co.'s research laboratory at Schenectady, was released for the emergency by his company to join the staff of the Zar Metallurgy Committee of the National Academy of Sciences, National Research Council.

✦ PAUL J. KUTZ, a graduate of Pennsylvania State College in 1942, with a B.S. degree, has been appointed to the staff of the Bakelite Corp. at its research development laboratories, Bloomfield, N. J. Other additions to the staff are: Charles H. Rector, Jr., graduate of De Pauw University in 1938, and Northwestern University in 1942, with a Ph.D. degree in organic chemistry; Harrie M. Quackenbos, Jr., with a B.S. degree from the University of London in 1938, and a chemical engineering diploma from the same university in 1939, and an S.M. degree in chemical engineering from the Massachusetts Institute of Technology in 1941; Joseph J. Smith, graduate of Fordham College in 1943 with a B.S. degree; Lawrence Maynard Baxt, with B.S. and M.S. degrees from McGill University, and a Ph.D. degree in 1939 from King's & Imperial Colleges, London.





✦ GEORGE H. SPENCER-STRONG has been appointed director of research of the Porcelain Enamel & Manufacturing Co., Baltimore, Md. Dr. Spencer-Strong succeeds Mr. Lyman C. Athey, who resigned recently to accept the position of vice-president of the International Products Corp.

✦ GEORGE K. MANNING, metallurgist, has been named to the research staff of Battelle Memorial Institute, Columbus, Ohio, and assigned to its division of metallurgical research.

✦ RALPH D. WILLIAMS, for the past 17 years with Hudson Valley Fuel Corp., a subsidiary of Niagara Hudson Power Corp., Troy, N. Y., has resigned as plant superintendent to become technical consultant with General Chemical Co.

✦ FRED SCHORKEN, of Manistee, Mich., is now at Cantonment, Fla., where he is technical director of the Florida Pulp & Paper Corp. plant.

✦ KENNETH W. COLE, of the Pressed Steel Tank Co., Milwaukee, has been granted a leave of absence by his company to accept appointment to the containers division of WPB, and will be located in Washington.

✦ ROBERT K. KULP has been appointed director of research by the Jessop Steel Co., Washington, Pa. He was formerly associated with the steel and tube division of the Timken Roller Bearing Co., and previous to that with Lukens Steel Co.

✦ HARRY R. MEYER has been named general manager of sales at By-Products Steel Corp. Mr. Meyer was formerly manager of direct sales for Lukens Steel Co., of which By-Products Steel is a subsidiary.

✦ GEORGE R. ATKINS has been appointed manager of the branch sales office and factory in Akron, Ohio, of the Bristol Co. Mr. Atkins attended Northeastern University where he majored in chemical engineering and was graduated in 1928. He joined Bristol Co. sales organization in 1929.

✦ W. S. TOPPING, who has been chief inspector of the Bureau of Explosives, retired on May 1 after 36 years with the Bureau. Mr. Harry A. Campbell, who has been assistant chief inspector, is appointed chief inspector.

✦ CHARLES R. DOWNS and MR. JOHN M. WEISS, after 30 years of association in business, the last 20 years of which as the firm of Weiss and Downs, Inc., in New York have set up independent consulting chemical engineering practice with offices at the Chemists' Club.

✦ ARTHUR A. WUEST, a chemical engineering graduate of Ohio State University, has joined International Minerals & Chemical Corp. as chief chemist at the Columbia Park, Cincinnati, plant. He was formerly engaged by Columbia Alkali Co. and Lunkenheimer Co.

Henry F. Johnstone

✦ HENRY F. JOHNSTONE, professor of chemical engineering, University of Illinois, Urbana, was awarded the 1943 William H. Walker award medal of the American Institute of Chemical Engineers at the 35th semi-annual meeting of the Institute in New York.

✦ DEXTER NORTH has retired from consulting chemical practice in Washington to become chief of the war production section in the division of patent administration, Office of Alien Property Custodian. Mr. North was for many years previously connected with the chemical division of the U. S. Tariff Commission.

OBITUARIES

✦ FRANK E. MCGINNIS, credit manager of Pennsylvania Salt Mfg. Co., Philadelphia was found dead in his apartment in that city on April 13.

✦ HARRY H. DE LOSS, a director of Handy & Harman, New York passed away March 28 at Clearwater, Fla.

✦ MAX W. BABB, chairman of the board of the Allis-Chalmers Mfg. Co. died March 13 in Milwaukee after an illness of several weeks. Mr. Babb who had been board chairman since January, 1942, and the company's president for the prior ten years, was 68 years old.

✦ W. J. WOOLDRIDGE died at his home near Pittsburgh April 6 at the age of 70. His last active business years were spent with Allegheny Ludlum Steel Co., Brackenridge, Pa.

✦ ELLWOOD B. SPEAR, associate professor of chemistry at Massachusetts Institute of Technology from 1910 to 1920, died May 1 of a heart attack at his farm at Milford, N. H. His age was 68.

✦ EMORY E. SMITH, consulting chemical engineer, died May 1 during a session of the Western Governors Conference at San Francisco. He was 76 years old. Mr. Smith had been closely associated with Stanford University since its beginning.

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MEETINGS AND CONVENTIONS

LANDIS RECEIVES MEDAL FROM AMERICAN INSTITUTE OF CHEMISTS

DR. WALTER S. LANDIS, vice president of the American Cyanamid Co., has been awarded the gold medal of the American Institute of Chemists for outstanding services to the science of chemistry. The medal is being presented to Dr. Landis not only in recognition of his contribution to chemical engineering and development work, largely in the field of nitrogen derivatives, but also for his services to the professional side of chemistry. The medal was awarded to Dr. Landis at the annual meeting of the Institute during May.

Among Dr. Landis' accomplishments is the development of a method for fixation of atmospheric nitrogen by producing ammonia from cyanamid and oxidizing to nitric acid. He engineered the first American plant for using this process, erected during World War I.

AMERICAN SOCIETY OF TESTING MATERIALS NOMINATES OFFICERS

THE NOMINATING committee to select nominees for officers of the A.S.T.M. met in Philadelphia, March 8. In accordance with the provisions of the bylaws of the society, the following nominations are announced: For president. Dean Harvey, Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.; for vice president, John R. Townsend, Bell Telephone Laboratories, Inc., New York, N. Y. Nominees for members of the executive committee were as follows: T. A. Boyd, Research Laboratories Division, General Motors Corp., Detroit, Mich.; William H. Finkeldey, Singmaster & Breyer, New York, N. Y.; E. W. McMullen, director of research, Eagle-Picher Lead Co., Joplin, Mo.; E. O. Rhodes, Tar and Chemical Division, Koppers Co., Pittsburgh, Pa.; Francis J. Tatnall. Baldwin-Southwark Division, Baldwin Locomotive Works, Philadelphia, Pa.

AMERICAN GAS ASSOCIATION HOLDS PRODUCTION AND CHEMICAL CONFERENCE

THE JOINT Production and Chemical Committee Conference of the American Gas Association will be held May 24 and 25 at the Hotel Pennsylvania, New York, N. Y., it has just been announced. Chairman of the Gas Production Committee is E. W. Zimmerman, Everett. Mass. A luncheon conference on the war emergency will be held at 12:30 p. m. on Tuesday, May 25.

Technical discussions include the following: "Two-Shell Water Gas Set" by D. S. Reynolds, vice president, Boston Consolidated Gas Co., Boston, Mass.; "Approved Apparatus for Rapid Determination of Traces of Carbon Monoxide" by Louis Shnidman, Rochester Gas & Electric Corp.; "Report on Organic Sulphur Research," by Dr. E. W. Guernsey, chairman, Subcommittee on Organic Sulphur, A.G.A.; "Water Gas" by P. T. Dashiell, the Philadelphia Gas Works Co.; "Chemistry in the Gas Industry," by Dr. F. H. Dotterweich, Texas College of Arts and Industries, Kingsville, Tex.; "Coal Carbonization," by A. C. Sedlachek, Philadelphia Coke Co.

Program for Tuesday includes addresses on "Postwar Purchasing Power and Potential Market," by C. V. Sorenson, Northern Indiana Public Service Co., Hammond, Ind.; "Factors Affecting Realization of Potential Market," by R. J. Rutherford, Worcester Light Co., Worcester, Mass., and R. E. Ginna, Rochester Gas & Electric Corp.; "Engineering and Economic Aspects of our Own Ability to Satisfy Potential Markets," by Hall Henry, Negea Service Corp., Cambridge, Mass.; "Effects of National Planning and Trends," by Walter B. Beckjord, Columbia Gas & Electric Corp., New York, N. Y. Also included in the program are "Nitric Oxide Removal at Boston," "Maintenance and Repairs During the Emergency," "Reformed Gas Oil." and "Gas Enrichment."

AMERICAN CHEMICAL SOCIETY PRESENTS AWARDS

TWO AMERICAN scientists were honored at the 105th meeting of the American Chemical Society in Detroit when the Borden Co. prize of $1,000 for research in the chemistry of milk went to Dr. Earle O. Whittier, senior chemist of the research laboratories of the Bureau of Dairy Industry, U. S. Department of Agriculture, Washington, D. C., and the $1,000 Eli Lilly & Co. prize in biological chemistry went to Dr. Herbert E. Carter of the University of Illinois.

Dr. Whittier was cited for his researches in the chemistry of milk constituents. His studies have been concerned with utilization of lactose and casein, chemistry of the manufacture and uses of lactic acid, acid-base equilibria and the buffer values of milk and milk constituents, oxidation-reduction equilibria in milk, and ionic equilibria which are fundamental to a knowledge of the stability of the protein system. Dr. Carter, who is 32 years of age, was cited for his studies of amino acids, the building blocks of proteins, and of fatty acids. He has synthesized a number of these acids and contributed to the knowledge of their metabolism.

INSTITUTE OF FOOD TECHNOLOGISTS TO MEET IN JUNE

THE FOURTH conference of the Institute of Food Technologists in St. Louis, June 2-4, will be a refresher course of study for over 500 food researchers and processors to cover the rapid advances which have been made in the food field under the impact of war. The army and navy will open the school by presenting the wartime needs of our armed forces. Research and industry will answer the challenge with a preview of the new foods to come.

The annual Food Technologists' dinner, the occasion of the award of the Nicholas Appert Gold Medal to the outstanding food technologist for 1943, will be a ration-free affair with dehydrated foods highlighting the menu.

CANADIAN CHEMICAL ASSOCIATION MEETS IN MONTREAL

THE 26TH annual meeting and technical session under the auspices of the Canadian Chemical Association, the Canadian Institute of Chemistry and the Society of Chemical Industry will be held in Montreal, Canada, on May 31 and June 1. A program of special interest to chemists, chemical engineers and chemical manufacturers in wartime has been arranged.

MANAGEMENT'S WAR PRODUCTION JOB TOLD BY COES

AMERICAN industry and management have already done an immense job and a good one towards meeting the war production challenge, but still greater effort must be put forth, said Harold V. Coes, president of the American Society of Mechanical Engineers, at the dinner of the spring convention of this society in Davenport, Iowa, April 27. Mr. Coes asserted that the United States has produced in about two years what it took Japan 30 years to do, Russia 20 years. and Germany 10 years. He called for cooperation, not conflict, between government and business and between management and labor. The dinner was the high spot of the three-day meeting of which "Meeting Production for Victory" was the theme. Another speaker at the dinner was Col. James L. Walsh, chairman of the War Production Committee of the American Society of Mechanical Engineers and a director of the Army Ordnance Association, who spoke on "Engineers Against Time." Col. C. E. Davies, secretary of the society and chief of the control division, Office of the Chief of Ordnance, Washington, D. C., presided at the dinner.

ELECTROCHEMICAL SOCIETY OPPOSES KILGORE-PATMAN BILL

A RESOLUTION adopted unanimously by the Electrochemical Society at its meeting in Pittsburgh, Pa., April 8-10, expressed general opposition to the enactment of any measure which embodies government supervision, regimentation and control of the scientific and technical resources of the nation in peacetime and urged that members of the Electrochemical Society examine the Kilgore-Patman Bill S-702, HR-2100, and communicate their views on it to their Congressmen. It was pointed out that enactment of this bill for establishment of an Office of Scientific and Technical Mobilization would confuse the war effort by creating at this time a new agency for the direction of the scientific and engineering program which is now so effective in the prosecution of the war.

NEW YORK ELECTROCHEMICAL SOCIETY NOMINATES NEW OFFICERS

The Nominations Committee of the New York Section of the Electrochemical Society, meeting April 30, nominated the following for 1943-44 officers: for chairman, Robert J. McKay, International Nickel Co., New York; for vice chairman, Dr. Lincoln T. Work, Metal & Thermit Corp., Rahway, N. J.; for secretary-treasurer, Dr. W. C. Moore, U. S. Industrial Alcohol Co., Stamford, Conn.; for executive committeeman, Frank Vosburgh, National Carbon Co., New York. Election of next year's officers will be held at the next meeting.

SELECTIONS FROM CONVENTION PAPERS

AGRIPOL: A NEW RUBBER-LIKE MATERIAL

During July, 1942, the procedure for preparing Norepol, a synthetic rubber-like material developed by the Northern Regional Research Laboratory of the Department of Agriculture at Peoria, Ill., was released to a selected group of companies interested in manufacturing or processing the material. Among these was Reichhold Chemicals, Inc., which has made further improvements on the product, and is now selling its material under the name of Agripol.

Principal raw material in the production of Agripol is usually soy bean oil. Other vegetable oils can also be used. In addition, a small amount of an alcohol derivative is required. A certain fraction of the vegetable oil fatty acids are combined with a glycol to give esterified fatty acids. This, in turn, is compounded with small amounts of carbon black, zinc oxide, sulphur and a rubber accelerator in the presence of heat to produce a spongy product. In case a white material is desired, the carbon black is substituted by titanium oxide.

This spongy product is turned over to the rubber compounder, who adds the customary materials used for natural rubber compounding. Agripol has a fortunate property in that it is adaptable for fabrication on present rubber equipment. Vulcanizing time and temperature are the same as for natural rubber, and it can be worked on existing rolls and formed in existing molding equipment. This same statement cannot be said for most of the synthetic rubbers in use today.

Agripol is not suitable for making tires, although recent experiments have indicated that it may have possibilities for recapping purposes. The use of Agripol in the field of static rubber has many possibilities. For example, tests have shown that it is equal or better than natural rubber at low temperatures, such as —40 deg. F. It is much superior to natural rubber in oxygen and ozone characteristics. In fact, the quality improves when exposed to either oxygen or ozone. The dielectric strength and corona resistance are also outstanding characteristics, being better than those of natural rubber. It is impervious to water and alcohol. Its resistance to oil, fuel and organic solvents is very similar to that of natural rubber.

Largest outlet for Agripol, at the present time, is in the field of gaskets for food closures. Due to its electrical properties, it makes an exceptionally good wire coating. Other large uses are for hose lining, proof goods, adhesives, sponge rubber, and as an extender for natural, reclaim and synthetic rubber. Due to the many rubber-like characteristics of Agripol, it can be used for molded and extruded products. It can also be produced and used in the form of an emulsion, here also behaving like natural rubber.

Present capacity for making Agripol by Reichhold plants is approximately 2,000,000 lb. per month, which is to be increased to 4,000,000 lb. by early summer, provided raw materials are allocated. If there is sufficient demand, and W.P.B. grants releases, Reichhold Chemicals can bring annual production to a minimum of 50,000,000 lb. per annum by the end of 1943.

Physical data of the finished product will vary according to compounding. Tensile strengths range from 250-1,275 lb. Elongations will run from 65-180 percent, and durometer (Shore A) from 40 to 90.

Andrew J. Snyder, Reichhold Chemicals, Inc., Detroit, Mich., at the Ninth Annual Chemurgic Conference, Chicago, Ill., March 24, 1943.

SPECIFIC RESISTANCE OF COMPRESSED GRANULAR REFRACTORY MATERIALS

A quick, economical method has been developed for the determination of the specific resistance of compressed granular refractory materials at temperatures up to 1,000 deg. C. The leakage resistance of tubular heating elements insulated with periclase has been found to be proportional to the resistivity coefficient of the grain used for insulation. The theoretical derivation and method of calculation of this factor are given.

The Joffe law,

$$R_s = Ae^{\frac{B}{T}} \text{ or } \log R_s = A + \frac{B}{T}$$

has been verified for periclase in the range 600 deg. to 1,000 deg. C. R_s is the specific resistance: A and B are constants; T the absolute temperature; and e, the expotential value 2.718.

Results of measurements on periclase of different degrees of purity are in general agreement with those obtained by Rochow and by Heine.

It has been shown that some additions to periclase, notably alumina, increase its resistivity to a very useful degree be-

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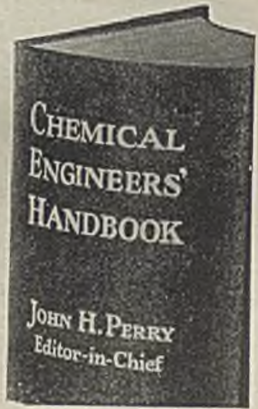

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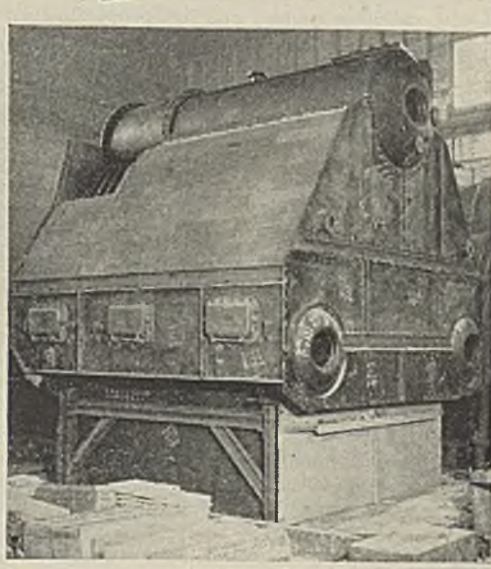

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low 1,000 deg. C, though the effect is probably opposite at very high temperatures. The presence of iron and boron has been shown to be especially harmful.

Periclase and especially alumina were found to show dielectric absorption effects. In the case of periclase containing alumina or spinel, the ratio of d.c. to a.c. resistance was found to be a function of the alumina content.

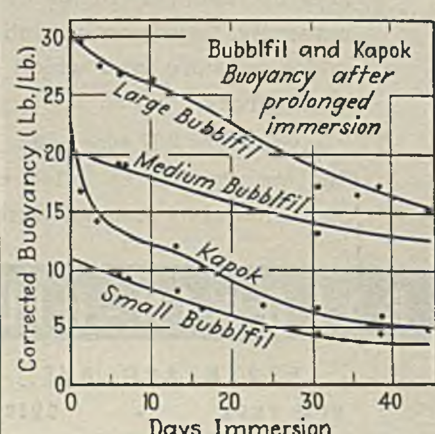
G. H. Fetterley, Research Development Laboratory, Norton Co., Chippewa, Ont., Canada, before the Electrochemical Society, Pittsburgh, Pa., April 8–10, 1943.

BUBBLFIL: AIR-IMPREGNATED CELLULOSE

BUBBLFIL, essentially, is a system of small air pockets firmly entrapped in a film of regenerated cellulose. It is produced in the form of an endless chain of disconnected bubbles, each bubble tightly sealed off from adjacent units. In raw material origin, it is comparable with viscose rayon, cellulose, cellophane, and cellulose sponge, and has properties generally similar with respect to aging, temperature, resistance to moisture, etc. But Bubblfil, chiefly because of its cellular structure and entrapped air, offers certain characteristics not commonly associated with these products. These may be summarized: (1) an unusually low ratio of weight to bulk; (2) flotation properties of a high order; (3) a significant capacity for providing heat insulation; (4) unique characteristics with respect to compressibility and resilience.

Bubblfil is spun in continuous lengths, thus allowing it to be used in single strands, portable strands, or tows, loose masses of any dimension, or blocks bonded with adhesives. The number of bubbles per meter, and the shape and size of the bubbles may be varied over a wide range, thus giving a flexible control of density, compacting, buoyancy, insulation and resilience. Gases other than air may also be entrapped, and various pigments and modifying materials may be introduced to change the appearance and properties.

Bubblfil may be considered for use in any one of several physical forms: (1) as a loose stuffing material in the same manner that down, kapok, excelsior and feathers are used; (2) stuffed or wound as parallel fibers into a mold, followed by treatment with an adhesive to yield a form which will retain a given shape; (3) parallel strands may be drawn through, as a rope or tow, a cloth, Fabri-



koid, or other impervious coverings or held in position while a cover is knitted or braided around it; (4) held in place between two fabrics by one of various processes known as quilting; (5) individual continuous strands may be woven as warp yarn and combined with other fibers used as filling yarns.

This material retains its buoyancy considerably better than kapok during periods of immersion. Tests made for periods of 45 days in fresh water at 25 deg. C., in 3.5 percent salt solution at 2 deg. C. and 35 deg. C., at normal and at 30 lb. per sq.in. pressure, have consistently shown that Bubblfil retains its buoyancy to a greater degree than kapok. Tests on the material as a replacement for kapok in standard Navy life jackets have shown that it can be used satisfactorily. On the other hand, it has no marked advantage over kapok and since this material is available at a lower price than Bubblfil, it is still being used.

Bubblfil is essentially "bullet-proof" since the buoyancy of the whole mass is not destroyed by the passage of a bullet. A series of tests have been run on Bubblfil as a replacement for Java kapok, which has been disallowed for this use by W.P.B. because of its relative shortage. Bubblfil has been found entirely satisfactory for this purpose and approved for use by the Coast Guard.

This material is also being tested as a substitute for cellular rubber in portable foot-bridges, for protection of electric devices and delicate instruments against breakage when dropped by parachute, and as a weatherstripping, shock and vibration-absorbing material. A resilient gasket for molding Lucite bomber windshields has been made which apparently functions satisfactorily as a substitute for rubber.

Bubblfil Properties Compared with Other Buoyant Materials

	Packed Weight lb./cu.ft.	Buoyancy In Water lb./cu.ft. Hrs. 0	24	In 3.5% NaCl lb./cu.ft. Hrs. 0	24
S.. all Bubblfil......	3.50	30.4	28.8	34.4	34.2
Medium Bubblfil...	3.50	48.1	47.0	48.9	47.8
Large Bubblfil......	1.63	30.8	37.5	41.7	40.5
Large Bubblfil......	1.25	48.2	45.6	45.4	44.6
Large Bubblfil......	1.31	39.4	37.7	43.8	42.4
Large Bubblfil......	1.29	48.8	45.8	47.2	46.8
Large Bubblfil......	1.79	43.4	43.0	42.4	42.5
Kapok............	1.75	44.5	44.5	45.3	45.3
Kapok............	3.00	58.6	45.0	57.3	54.6
Foamed glass.......	11.2	51.0	25.9	....	....
Cellular rubber.....	4.62	59.8	48.4	....	....
Cork..............	15.6	57.2	....	....	....

Bubblfil has excellent heat insulation properties provided it is backed by windproof fabrics to prevent transmission of heat. Two layers of a very loose Bubblfil fabric, a total thickness of less than ¼-in., backed by a layer of aluminum foil, have been shown to be the equivalent of a ¾-in. pile sheep shearling. A mass of random Bubblfil is approximately equivalent to a corresponding mass of down in thermal insulating properties. The real superiority of Bubblfil is brought out in uses involving compression of the insulating material such as occurs at the shoulders and elbows of wearing apparel and under the hips and shoulders in military sleeping bags. Under these conditions, Bubblfil is superior to down since it resists compression and retains the necessary thickness for insulation. One very interesting possible application of the material is as an insulating material to line aviator's jackets.

J. B. Quig, E. I. du Pont de Nemours & Co., Wilmington, Del., before the American Association of Textile Technologists, New York, N. Y., December 9, 1942.

RECOVERY OF MANGANESE FROM LOW-GRADE ORE

An investigation has been carried out to develop a commercially feasible process for concentration of one of the low-grade manganese ores of the United States. The ore selected was that of the Chamberlain district of South Dakota.

This deposit is the largest known in the United States, recent estimates showing conservatively some one billion tons of metallic manganese. The ore consists essentially of nodules, averaging one to three inches in diameter, scattered through a surface bed of shale 35 to 40 ft. thick. Approximately 10 percent of the volume of the deposit is composed of nodules. The ore, on being exposed to the air, undergoes weathering with the result that the nodules easily break away from associating shale. Since manganese content of the mixed shale and nodules averages less than 2 percent and that of the nodules 15-20 percent, a remarkable concentration of manganese is effected by this physical separation.

Chemical tests conducted on the nodules indicate that all manganese was present as carbonate, except for a mere trace present as oxides. Only about 50 percent of the iron was present as carbonate. All the calcium cannot be present as carbonate, and apparently some is combined with alumina and silica.

Roasting of nodules at temperatures of 400-550 deg. C. results in rapid decomposition. Removals of 94 and 97 percent of the CO_2 content of the ore are accomplished by roasting for 30 min. at 600 deg. C. and for 20 min. at 650 deg. C. respectively. Mesh size has no effect on degree of decomposition. The nodules decrepitate strongly during roasting, giving a calcine nearly all of which is less than 5 mesh.

By using a direct, countercurrent leaching system of four stages with a ratio of water to calcine of 2:1 and filtration between stages, a product liquor containing 8.5-9 percent manganese may be obtained. This liquor contains negligible silica and only ½ percent of the other major impurities, such as calcium, iron and phosphorus. Modified countercurrent leaching systems are capable of yielding more concentrated liquors, but require many stages to give a high recovery.

A minimum ratio of water to calcine of 2:1, and a minimum of four stages are necessary. Calcine of 35-48 mesh is suitable from the standpoint of physical characteristics and leaching rate. Maximum temperature resulting from exothermic reactions during leaching does not exceed 55 deg. C. for a 2:1 ratio. Leaching time of 20 min. per stage is required when using pure SO_2 (for 2:1 ratio and excess sulphurous acid); times of about 48 min. are required when using gas mixtures containing 11.7 percent SO_2. Washing with 2 lb. of water per pound of tailings is a minimum for satisfactory operation. Use of decantation or filtration between intermediate stages is dependent on an economic balance of several factors.

As a means of concentrating low-grade ore of the Chamberlain district, the process of roasting, followed by countercurrent leaching with sulphurous acid, appears feasible. Treatment of the product liquor, as also the initial separation of shale from nodules, may be carried out according to methods previously developed.

H. C. Weber, Department of Chemical Engineering, Massachusetts Institute of Technology, and C. H. Davenport, Standard Oil Development Co., Elizabeth, N. J., before the American Institute of Chemical Engineers, New York, N. Y., May 10-11, 1943.

WORLD CONSUMPTION OF PETROLEUM AND SUBSTITUTES DURING 1942

Estimates of world output of crude petroleum and substitutes reflect to some extent world consumption. Such estimates for 1942 indicate production of 2,208,000,000 bbl., or 171 million less than in 1941. Estimated production of substitutes increased nearly 20 percent. In the United States crude output was down less than 2 percent, while that in foreign countries declined over 20 percent. Marked decline abroad reflected losses in Venezuela and Colombia, due to shortage of tankers, and in the East Indies and Burma, due to military invasion and destruction of properties. Indicated production of substitutes in 1942 was a new high of 7.5 percent of the world output.

Important changes have occurred in supply of Axis countries. In Japan the output for 1941 was estimated at 8,800,000 bbl., of which 5,500,000 was substitutes. Synthetic production probably increased in 1942 and raised total interior production to 10,000,000 bbl., while the Japanese gained possession of oil fields having normal output of 78,000,000 bbl. annually. Production of those areas for 1942 is estimated at 23,000,000 bbl., indicating Japan now gets at least 33,000,000 bbl. a year, or 8,000,000 bbl. more than peak peacetime consumption. Dutch East Indies and Burma fields would leave Japan no difficulty on sources of supply, and the greatest problem would be ocean transportation and refining equipment.

Output for European Axis countries and controlled areas was up 20 percent from 1941. Germany is steadily increasing synthetic oil production, many reliable sources report. Estimates average 46,000,000 bbl. for 1942 and indicate nearly half of the present supply as being substitutes. This may indicate ineffectiveness of bombing synthetic plants or concealment of widely distributed plants from aerial attack. Rumanian production is 35 percent of European

Axis output, and being confined to a small area, leaves Germany vulnerable to heavy loss by continuous bombing.

An average of European Axis consumption estimates is 13,000,000 bbl. per month during active military operations and 9,000,000 monthly between campaigns. This indicates that small accumulations are possible when military operations are passive but that reserve oil stocks shrink considerably when operations are active. Nevertheless, difference between petroleum supply and demand for European Axis powers cannot be great, and extensive efforts are justified toward destruction of Axis sources of supply.

V. R. Garfias, R. V. Whetsel, and J. W. Ristori, Cities Service Oil Co., before the American Institute of Mining and Metallurgical Engineers, 157th Annual Meeting, New York, N. Y., Feb. 14-18, 1943.

PROCESSING WATER FOR GRAIN ALCOHOL DISTILLERIES

Grain alcohol distilleries use water from either well or surface supplies and in many cases from both. Boiler waters are softened by standard procedures. Well waters are preferred for processing, that is, cooking, preparation of the yeast, and fermentation, because they contain mineral salts required by the yeast. In a modern large distillery employing pressure cooking, temperature control of yeasting and fermenting operations, and continuous stills, the water requirement will run about 270 gal. per bu. at temperatures of 50–60 deg. F.

Cool waters are preferred for all cooling operations which means that during the warm months of the year well waters are preferred over surface supplies running 80–90 deg. F. Surface supplies are preferred during the cooler months because they are usually less mineralized and do not require treatment. Well waters used for cooling are treated with sulphuric acid or metaphosphate to remove or stabilize the bicarbonate hardness and thus eliminate formation of carbonate scale in the cooling equipment.

Where there is a shortage of cool well water, distillers are practising mechanical cooling of surface supplies through refrigeration or reduced pressure. Most distillers are practising the reuse of water to conserve heat as well as water.

For the complete recovery of grain by-products, which means the operation of evaporators, it requires about 400 gal. of 70 deg. F. water per bushel of grain to produce the necessary vacuum in multiple effect evaporators equipped with modern steam ejectors.

Bernard Smith, M. G. Walker, and C. S. Boruff, Hiram Walker & Sons, Inc., Peoria, Ill., before the 105th annual meeting of the American Chemical Society, Detroit, Mich., April 12–16, 1943.

CATALYTIC CRACKING BY THE FLUID CATALYST PROCESS

When oils are cracked, carbon is deposited on the catalyst, reducing its activity and making necessary its removal by burning with air. In the fluid catalyst cracking process the catalyst is handled as a fine powder in such a way that it is kept in a fluidized condition at all times, in which form it may be handled substantially as a liquid. The catalyst is conveyed through the reactor by the oil vapor, after which it is separated in dust recovery equipment, with the product vapor flowing to conventional distillation equipment. The carbonized catalyst then flows down a standpipe in a high density condition, whereby its pressure is increased sufficiently to permit injection into a stream of air, which carries it to the regenerator. In the latter, the carbon is burned off, after which the catalyst is separated and the flue gas vented to the atmosphere. The regenerated catalyst then passes down a second standpipe and is injected into the oil vapor going to the reactor. The process is thus completely continuous as regards oil, air, and catalyst flow.

Operating conditions in the process may be adjusted to production of war products such as high-octane aviation fuel, butylenes, and toluene. Gasoline fractions from the operation may be used directly as aviation base or reprocessed in the fluid catalyst unit or hydrogenated. Aviation fuels produced by these methods have low alkylate requirements and when so blended, and after addition of lead tetraethyl, meet highest grade aviation fuel specifications. The motor gasoline has a octane number of 92-94 by the CFR Research method.

Three commercial plants are now in operation and have given very satisfactory performance. A large number of additional commercial units are under construction.

In the field of metallurgy the temperature control and ease of handling which can be obtained through application of fluid catalyst principles may be of value for reduction of iron ore and for the roasting and smelting of various ores. Experimental work has indicated that excellent temperature control can be obtained through use of the fluid catalyst principles in oxidation of organic compounds, and particularly for the production of phthalic anhydride from naphthalene.

E. V. Murphree, C. L. Brown, H. G. M. Fischer, E. J. Gohr, and W. J. Sweeney, Standard Oil Development Co., before the Division of Petroleum Chemistry of the American Chemical Society, Detroit, Mich., April 12-16, 1943.

• • •

The foundation upon which the administrative chemical engineer must build, in addition to his professional training, involves certain abilities which are partly natural and partly acquired. Technical and engineering work can be carried on, if not in a business vacuum, at least behind the screen, but administrative direction involves relations with other people. Preparation for administrative engineering work cannot be obtained wholly from books and, if at all, to only a limited extent in schools. The ability to grasp essential facts from an extended treatise and to summarize essential conclusions in cogent language is an asset in communicating ideas to others that it would be very difficult to over-emphasize. This ability can be enhanced during the period of preliminary professional training.

SYNTHETIC RUBBER
AUTOMATIC CONTROL

Pushing a tiny button, the operator of the control board activates the Bristol instruments which started production of synthetic rubber in the United States Rubber Company's New England plant.

BRISTOL'S LONG EXPERIENCE WITH CHEMICAL PROCESS INSTRUMENTS NOW HELPS SPEED SYNTHETIC RUBBER PROGRAMS....

The synthetic rubber program, with all its vast implications in the present emergency, is essentially dependent on automatic controls — which *alone* can insure that the correct procedure is repeated with the same precision day after day.

The original work done by Bristol engineers in collaboration with the designers of synthetic rubber plants has resulted in the development of a series of automatic control instruments for temperature, flow, flow ratio, pressure, pH value, and time cycle specifically designed for the problems involved. These instruments have been correctly applied and are now in use in plants producing synthetic rubber and raw materials for synthetic rubber.

The work done by Bristol engineers in producing instruments for the synthetic rubber program is typical of what has been done in many other industries, particularly in the chemical industry.

Installations have been made, particularly for catalytic dehydrogenation and polymerization. Bristol pH controllers, with Beckman shielded glass or calomel electrodes, are also in use in coagulation and stabilization processes. Several installations have already been proven in action over a considerable period of time.

Possibly you have a problem which may best be solved by more accurate, automatic controls of time, temperature, pressure, humidity, liquid level, pH or flow. Perhaps, too, you will be able to increase the value of your entire instrument investment with Bristol's system of Coordinated Process Control, which automatically controls the whole process according to fixed schedules. Pioneering, practical, production-minded Bristol engineers may be able to help you. Write for further facts.

THE BRISTOL COMPANY

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AUTOMATIC CONTROLLING AND RECORDING INSTRUMENTS

BRISTOL *Engineers Process Control for Better Products and Profits*

NEW PRODUCTS AND MATERIALS

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"Dry" end of infra red ray ball powder dryer at plant of Western Cartridge Co.
Ball powder is a smokeless powder made by a new process under water five times faster than ordinary smokeless powder. After its manufacture, it is fed upon an endless belt which passes under a long bank of infra red lamps so adjusted that rays penetrate powder and evaporate water. Operator is shown feeding dried powder into cannisters following drying

SMOKELESS POWDER BALLS

Ball powder, a smokeless gun powder in the shape of minute spherical pellets, is being made by a new process five times faster than that for ordinary smokeless powder. It was developed by the technical department of the Western Cartridge Co. headed by Dr. Fred Olsen. It is made under water, which reduces hazards to a minimum. This material and process have been one of the industry's closely guarded secrets. The East Alton, Ill., plant was constructed with phenomenal speed and produced the first powder in September, 1940, four months after ground was broken. Since that time more than one billion cartridges for the United States and other Allied Nations have been loaded with the new type powder.

In the production of ball powder nitrocellulose is produced in the conventional way by the use of nitric and sulphuric acids. While immersed in ten times its bulk in water, the nitrocellulose is reduced to a pure liquid form by various chemicals, including ethyl acetate. Being lighter than water, the gelatinized nitrocellulose rises to the top of the water as a creamy lacquer. By stirring the mixture the nitrocellulose lacquer acts in water very much as olive oil does in vinegar and forms into globules—the tiny ball powder pellets. Other chemicals are added to the mixture to prevent the balls from reuniting with each other when the stirring is stopped. By controlling the speed of stirring, the powder balls can be made in a great variety of sizes suitable for a wide range of ammunition sizes.

The basic Ball powder patent, U. S. 2,027,114, introduces a number of completely new concepts into the manufacture of smokeless powders.

The first of these which appears is the possible use of unstable nitrocellulose materials or deteriorated powder as the base material without purification outside of the process itself. This is made possible by the introduction of neutralizer and stabilizer materials directly in the first steps of the process. The placing of the base material into a solvent allows an almost instantaneous intimate action of the neutralizer and stabilizer materials resulting in a stability of product only achieved by long treatments in other methods.

The conventional ideas of powder grains formed into cylindrical particles by extruding through dies and cutting are completely abandoned in the ball powder process whereby the base-solvent lacquer is agitated in a non-solvent medium, such as water, to give spherical particles of uniform size and shape. This idea of grain formation has a most practical advantage when it is realized that the same equipment can be used to give a great variety of sizes of particles by simply varying the process conditions of material ratios and agitation.

The simple formation of identical spherical particles of nitrocellulose is, of course, not sufficient for the manufacture of military smokeless powder. It is also necessary that these grains possess the desired characteristics of potential and of burning rate, and the ball powder process lends itself well to the control of these factors. Nitrocellulose of various degrees of nitration (and hence potential) may be used. Or various potential modifiers may be used to accelerate or deter the action either by incorporating these modifiers in the original grain formation or by adding in separate steps. Surface treatment in either the wet or dry state is a simple controllable operation. And here again changes in the methods in application allow a high degree of flexibility in determining the nature of the finished product.

The idea of grains of a spherical shape may be readily seen to possess distinct advantages insofar as the blending and loading of the powder are concerned. First of all an almost absolutely accurate control of size may be exercised with spherical particles by the use of the most simple screens. Furthermore, spherical particles of the same size and density have flow characteristics such that a high degree of uniformity in blending is possible. These same characteristics make the loading of the powder into the shells a much more precise operation.

There are several features of the ball powder process. Chief among these are safety and economy. Although working with a potentially unsafe material, the process permits the greatest portion of the operations to be carried out under

FOR THE SYNTHETIC RUBBER PROGRAM..

Specialized Steel Storage Facilities by

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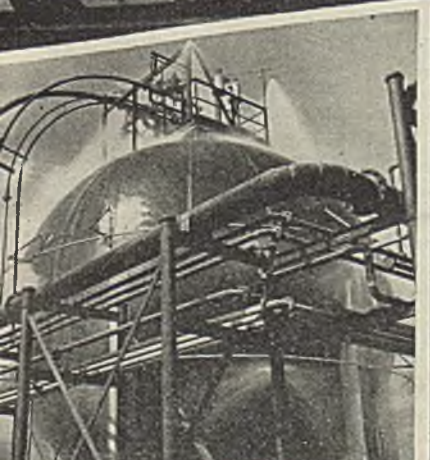

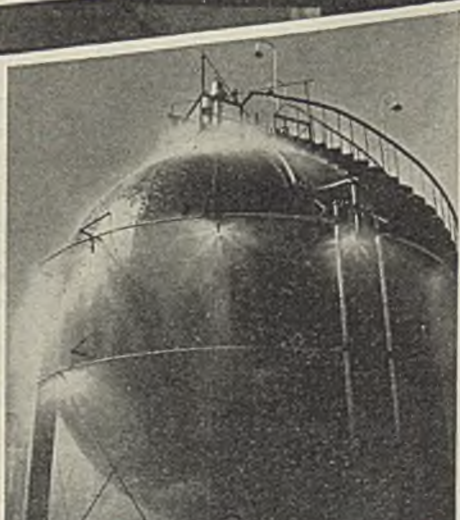

Through careful research and development, Pittsburgh-Des Moines is equipped to design and supply facilities for the storage of butadiene, styrene, isobutylene, acrylonitrile and other substances to fit your process—including tanks required at various steps.

These spheres, for storage of butadiene under pressure, were fabricated and erected by P·DM at one of the first Buna-S synthetic rubber plants built and operated for the government by United States Rubber Company.

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water. Indeed, from the very start of ball powder manufacture until the actual drying of the finished powders, the base materials are handled in water slurries. This constitutes a safety feature not found in any of the conventional practices.

It is a particularly happy circumstance that this handling under water not only gives a safe process but a time-saving one as well. Today finished ball smokeless powders are being made from raw nitrocellulose in a little more than three days' time—one-fifth of that of extruded powder methods. The economies made possible by the use of the less highly purified base materials, the greatly simplified equipment, and the relatively short manufacturing period are easy to derive.

BRISTLELESS PAINT BRUSH

Resin-oil emulsion paints may now be applied by a new roller-coating device developed for this application. With brushes expensive and getting scarcer, paint users—both professional and amateur—are interested in the development of the new paint roller introduced recently for the application of emulsion-type paints. Made entirely of non-critical materials, this type of applicator is much less expensive than a paint brush of similar size. It is extremely easy to use on walls and ceilings.

In working with the roller-coater, the paint is placed in a flat-bottomed pan, propping up one end so that the paint stays in the lower end. The roller is then dipped into the shallow edge of the paint and rolled toward the upper end of the pan until its fabric surface is completely covered. The final step is to roll the paint right onto the surface, leaving a fine-textured surface.

DETERGENT

The new detergent Alconol is described as a cleanser, which unlike strong soaps or alkalis whose action is purely chemical, relies on physical action for its detergent value by lowering the surface tension of foreign matter adhering to the surface of the utensils to be cleaned, according to the announcement by Standard Scientific Supply Corp., New York, N. Y. Although it contains no soap, Alconol is said to produce an abundant, highly efficient lather in water of any degree of hardness without the formation of insoluble calcium soap. It is claimed that Alconol will lather readily in acid solutions. Also, unlike soaps or strong alkalis, the surface tension depressant of this material is so great that no film is left on the glass. As a matter of fact, if glassware is left in an inverted position for a few moments, towel wiping may be eliminated for all practical purposes. Grease stained glassware and metalware respond readily to this preparation. It is packed in dry form and is available in 3-lb. packages or in bulk. An adequate solution is prepared by adding one ounce of Alconol to one gallon of warm tap water.

OFFICE PARTITION

Because of the development of a plastics and wire screening material to reduce wartime danger from flying glass, the postwar business executive will be able to change the size and arrangement of his private office as easily as his wife now shifts the living room furniture.

The war-born glazing which promises to add new flexibility to postwar offices is Reinforced Vuelite, two sheets of transparent cellulose acetate plastic laminated to standard wire screening. Developed by the Plastics Division of Monsanto Chemical Co. in cooperation with the United States Navy, it reduces the danger of flying glass during air raids or enemy bombardment. Use of the material in postwar offices was predicted after the Ensign-Bickford Co. installed it in office doors of its Simsbury, Conn., plant which manufactures safety fuses. The installation originally was simply a safety measure and the glazing was placed in conventional wood doors. Executives, however, were impressed by its combination of light weight, strength and resistance to breakage. Installed in suitable, lightweight frames, they suggested, it should be ideal for office partitions.

As manufactured for war uses, Reinforced Vuelite has a transparency about equal to that of a screened window of glass. In this form, it provides some degree of privacy for Ensign-Bickford executives at the same time it allows them to keep an eye on the outer office. For postwar office partitions it could easily be made less transparent if desired.

Other characteristics which recommend the plastics glazing for interior use are good heat-insulating and excellent sound-deadening properties, while official tests indicate it has sufficient strength to withstand the blast of a 150-pound bomb exploded only eight feet away.

A NEW ALCOHOL

Trimethylcyclohexanol, cyclic primary alcohol recently developed by the Carbide & Carbon Chemicals Corp., New York, N. Y., is now available in limited quantities. Trimethylcyclohexanol boils at 198 deg. C. and melts at 35.7 deg. C. Since this is about room temperature the product may be a liquid or solid. It is practically insoluble in water but soluble in most organic solvents, hydrocarbons, and oils. As a mutual solvent and coupling agent for many otherwise immiscible organic chemicals, it makes an excellent replacement for cresylic acid, cyclohexanol and cyclohexanone.

Being a higher alcohol, trimethylcyclohexanol should prove useful as an anti-foaming agent in the manufacture of hydraulic fluids and textile soaps. It may also be used in making plasticizers, xanthates, and wetting agents.

METHOXYTRIGLYCOL ACETATE

In research quantities for laboratory investigation, a new ester, methoxytriglycol acetate or the acetate of methyl ether of triethylene glycol $CH_3(OCH_2CH_2)_3OCOCH_3$ is now available from the Carbide and Carbon Chemicals Corp., New York, N. Y. This ester, a colorless liquid, has a boiling point of 244 deg. C. at 760 mm. Because of its structure, methoxytriglycol acetate has excellent solvent powers for cellulose esters and synthetic resins. This property indicates that it probably will be useful in protective coatings and printing inks. Because methoxytriglycol acetate contains no reactive group, it will undoubtedly prove to be useful as an inert reaction medium and because of its low volatility and non-hygroscopicity, it has possibilities as an "anti-dusting" agent for finely powdered materials.

SYNTHETIC RUBBER INDUSTRIAL TIRES

Successful application of synthetic rubber to industrial tires in operation in one of the country's largest steel mills is reported by the B. F. Goodrich Co., Akron, Ohio. Four experimental tires, constructed entirely of synthetic rubber were built, two of the 22x16x16 and two 22x12x16. They are of the Press-On type, for use on industrial power trucks and are being operated in the plants of the Jones & Laughlin Steel Corp. at Pittsburgh.

Latest reports on the tire performance is that they are holding up as well as tires made of natural rubber which previous to the rubber shortage were used in this type service.

BOTTLE SEALING CAP COMPOUND

A cellulose sealing cap similar to that used for sealing medicine bottles has been instrumental in saving many man-hours of labor in one of General Electric's plants producing small instrument-type motors. It is used to mask off cylindrical surface areas of small assemblies during impregnation with insulating varnish.

The sealing material comes in the form of a thin-walled tube or cap, either of which may be slipped over the work. In air-hardening, the material shrinks evenly to the point where it closes down over the surface to be masked, preventing the impregnating fluids from contacting the masked surface area. The area so masked requires little or no subsequent cleaning, and as a result, a shortened production cycle is possible with a coincidental saving of man-hours.

SEED DISINFECTANT

Recently, search for a suitable nonmetallic chemical compound for use as a seed disinfectant has been successful, according to the announcement of E. I. DuPont de Nemours & Co., Wilmington, Del. A new compound containing tetramethyl thiuramdisulphide known as Arasan is now offered for peanuts, vegetables and certain other crops. Experimental results show that Arasan effectively reduces losses in stands of peanuts resulting from seed decay, and of vegetables from damping-off and other fungous diseases. The tests indicate a wide range of possibilities as a disinfectant and protectant for soybeans, cowpeas, velvet beans, and grasses.

Bayer-Semesan recently announced a new non-mercurial turf fungicide containing tetramethyl thiuramdisulphide, trade-marked Thiosan, to control brown patch and dollar spot diseases in the bent grasses generally used for golf courses. This product has the same general characteristics as Arasan, but disperses readily in water for easy spray application.

SYNTHETIC INSECTICIDE

A new synthetic insecticide for fighting the insect menace which this year promises to become a major farm problem due to shortages in imported natural insecticides, was announced recently by Rohm & Haas Co., Philadelphia. It is hoped the newly developed chemical will help avert the widespread vegetable crop destruction threatened by the acute shortage of rotenone, heretofore the standard protection against many farm insects. Farmers can stretch available rotenone supplies by incorporating the new insecticide called Lethane 60, in standard dusts. Tests at several state truck farm experiment stations have shown that addition of 2 percent Lethane to dusts cuts in half the amount of rotenone necessary to do an effective insect killing job. The new Lethane has been developed far beyond the emergency stage. Experiments at the Virginia Truck Crops Experiment Station, Onley, Va., have shown 2 percent Lethane and 4/10 of 1 percent of rotenone to be actually more potent than standard prewar rotenone dusts, which contained anywhere from nearly double to three times that amount of rotenone.

GREASEPROOF PAPERS

A flexible, greaseproof paper Cellutin is being made in an eastern mill for the food industries. It is produced by impregnating and coating strong bleached stock. It is claimed by the Cellulose Products Laboratory, Division of the Richhaven Co., Tacoma, Wash., to be able to resist turpentine and mineral and vegetable oils for more than 96 hr. It tests 100 percent mullen and has high folding properties.

Celluduc is an impregnated paper having high waterproofness. Nearly any base paper may be used, including glassine. When converted to a bag it will hold water for more than 48 hr. and has high water repellency. Glassine and greaseproof papers, so treated, have a W.V.P. of 0.41 g. per 100 sq.cm. per 24 hr. (Using G.F.M.V.T. type cabinet.) There is no change in the strength of the base papers when treated.

Both types of paper are odorless, tasteless and nontoxic and are available in quantities and a certain percentage of production may be obtained without priority from Herman Scott Chalfant, Inc., New York, N. Y.

SKIN PROTECTOR

A new discovery comes to help fend off the misery of industrial dermatitis. AleXitE is a micaceous mineral, inert, purified by millions of years of volcanic heat and pressure, found only in one place high up in the Colorado Rockies. A special grinding-flotation process has broken it down to a fine powder, each microscopic particle of which is plate-like. They overlap each other like the millions of scales on fish, giving the same kind of armor protection that God gave fish. With AleXitE powder as the base, chemists and research engineers of the AleXitE Engineering Co., Colorado Springs, Colo., have developed an easy to apply and remove cream that will protect workers from the danger of dermatitis. It guards against fumes, scale, dust, iron oxide, actinic rays of sun and welder's glare, wind, paint, ink, most stains and other skin irritants.

LATEX SUBSTITUTE

In answer to the demand for a true substitute for natural latex, the Union Bay State Co., Cambridge, Mass., has developed Ubatex. It is said to be a milestone in the research which will lead to the ultimate manufacture of such a product. It is a dispersed polymer at high concentration and low viscosity, so prepared that it gives a strong, flexible film. It is a new compound and resembles latex only in some of its characteristics. The particle size is in the vicinity of four microns and is of the order of fineness of latex particles. As the pH of the dispersion is 9, it is easily coagulated or "set" by acid surfaces such as leather, thereby preventing undue penetration. However, like natural latex, reductions of concentration, aided by wetting-out agents similar to those used for latex, will give excellent impregnating compounds. The dry film is insoluble in water, but completely soluble in the aromatics and esters, while only partially soluble in ketones and petroleum. The film absorbs less moisture than rubber latex without losing appreciably in strength, is elastic, and on stretching will regain its former state. The principal difference between rubber latex and Ubatex lies in the fact that although it is an alkaline dispersion, the compounding is different. Although proteins, starches, and gums can be added to modify viscosity, penetration, etc., the practice, as developed for latex, does not apply in the same way. Once this fact is understood clearly, the compounding of Ubatex becomes an interesting study, for no longer do prejudice and preconceived ideas prevent the attempt to use some of the chemicals which are still available. It has been found that Ubatex can be modified to cover a wide scope of applications. However, at the present stage of development it is not pressure sensitive. The film at its maximum strength is not tacky and to date attempts to render it such with plasticizers only result in a loss of strength. Compounds of this material can be made suitable for coating and because of the degree of thermoplasticity can be regulated, heat-sealing wrappers are feasible, according to the announcement by Paul M. Fleuriel chief chemist, in the April 1943 issue of *India Rubber World.*

RESIN

Designed especially to develop fast through-dry with linseed oil is Pentalyn-M, Hercules Powder Co.'s newest resin of the rosin-pentaertythritol series. Varnishes made with Pentalyn M and "soft oils" such as linseed, develop a more complete through-dry than heretofore possible. The rapid top-dry common to all the Pentalyn resins is retained, as is the pale color of the finished varnishes. This new resin permits faster cooking procedures, which means either cooking less viscous prebodied oils for the normay period or materially shortening the cook when starting with heavier-bodied oils. This outstanding combination of good characteristics indicates a wide range of usefulness for Pentalyn M. Many varnish manufacturers have tested this material in their laboratories and are working out important additions to their lines as a result of such tests.

ASPHALT SUBSTITUTE

Asphalt has moved into the list of scarce and restricted materials. Much of this material is urgently needed for airport runways and other important military purposes, and its transportation is by that "rara avis," the railroad tank car (much sought after because of fuel oil and gasoline demands). Recent research has revealed a possible answer—or at least a palliative—to this situation. Abalyn and Belro Resin made by Hercules Powder Co., Wilmington, Del., blended with Gilsonite (mineral pitch, sufficiently high-melting to be transported in ordinary box-cars) can be used to develop a set of properties that will match those of a wide range of commercial asphalts.

SYNTHETIC RUBBER

A new type of synthetic rubber, Hycar OR-25, it is claimed retains the same ease of processing and compounding as OR-15. In addition, the new compound imparts to its vulcanizates the extremely valuable properties of low temperature flexibility at 15 deg. F. lower than is possible with equivalent OR-15 compounds and has a greater swell in gasoline and oil than OR-15, as required in many applications. The tensile strengths of the new compound stocks are generally lower than OR-15 stocks by from 350 psi. when soft blacks are used to 900 psi. when channel blacks are used. Elongations are also lower and a lower durometer hardness permits greater loadings to obtain the same hardness, it is reported. Specific gravity is 0.98; lupke rebound is about 15 to 20 percent higher and compression set is also somewhat better than similar Hycar OR-15 compounds. Air oven aging at 212 deg. F. indicates that stocks from both grades have equally good heat resistance, according to the Hycar Chemical Co., Akron, Ohio. (*India Rubber World*, April 1943, p. 51.)

MICA SUBSTITUTE

A plastic which has been given the name Polectron is now available for use where mica has previously been incorporated. It resembles actual mica only in that it possesses the ability to resist heat and to insulate against electricity. It has been developed by General Aniline and Film Corp., New York, N. Y. A plant to make the new material is being constructed at the present time. It will turn out the sheets of Polectron. The melting point of the new material is about 300 deg. F. so that it will stand the heat generated by high-frequency electric current. Also, it has an insulating capacity comparable to mica. It can be used in the same production line as sheet mica. Among its weaknesses is the brittleness.

ALUMINUM CLEANER

One of the first of a new line of cleaners and polishers to be put on the market by the Club Aluminum Products Co., Chicago, Ill., is Club Aluminum Cleaner, which comes in the form of a dry powder. Though it is formulated as a household item, it will be found to have industrial applications wherever steam stains, mineral discoloration, burns in grease, and other aluminum blemishes are a problem.

GASKET MATERIALS

Among the new materials in the gasket field is a product with a sponge rubber core and smooth outside coating of natural or synthetic rubber. The material is being used at the present time only for war products, but eventually will be used in refrigerators, automobiles and other products of the postwar era. It is made by molding the sponge rubber filler in slab form, slitting into strips and feeding through an extruding machine to produce a smooth outer covering to specified thickness. Cross-section shapes may be round, square or rectangular. At the present time the range of dimensions is from ¼ in. to 1½ in. while 12 ft. is the maximum production length. The new gasket material according to B. F. Goodrich Co., Akron, Ohio, is made from Amerpol synthetic rubber as outer covering which yields several distinct advantages. The new gasket will not succumb to the destructive acids of oils and greases, nor will it deteriorate when exposed to extremely low temperatures. Furthermore, this product is said to have a much more permanent set than tubular types previously used on refrigerators and automobiles, though it is just as soft and will depress as well as the older types.

REDWOOD PLASTICS

A new non-critical phenolic type thermoplastic from redwood is now available in large quantities for both war and civilian production. The new redwood plastic embodies in one composite form both resin and filler employed in the mold'ng of an endless variety of products. It is adaptable to either compression molding or the standard equipment of hard rubber plants. After extensive tests it was found to produce finished products of excellent tensile strength and attractive appe; rance. When special properties are desired it can easily be mixed with other resins and plasticizers with control of the formulation ingredients. The development of this plastic was shared by the Pacific Lumber Co., San Francisco, The Institute of Paper Chemistry, Appleton, Wis., and the Sheller Manufacturing Corp., Portland, Ind. The product is known as Shellerite.

UNUSUAL SOLID PLASTICIZERS

Dehydranone (dehydracetic acid) is a white camphor-like water-insoluble solid, which is compatible with nitrocellulose, polystyrene, methacrylate, and vinylite resins. At present this new synthetic organic chemical can be supplied in research quantities only. This product was developed by Carbide & Carbon Chemicals Corp., New York, N. Y.

Chemical	Molecular Weight	Boiling Point °C. at 760 mm.	Vapor Pressure in mm. Hg. at 20° C
Polyethylene Glycol 200	200 avg.	—	<0.01
Polyethylene Glycol 300	300 avg.	—	<0.01
Polyethylene Glycol 400	400 avg.	—	<0.01
"Dehydranone"	168.06	Melts 108	<0.1

CALCIUM SILICATE PIGMENT

Among the new developments of the Columbia Chemicals Division, Pittsburgh Plate Glass Co., Pittsburgh, Pa., is a chemical pigment, a white finely divided precipitated hydrated calcium silicate, with the following approximate analysis: Calcium oxide, 19 percent, and silica, 67 percent. Loss on ignition is 14 percent. Silene is composed of very fine particles at present in the form of small highly friable agglomerates that are readily dispersed in the course of milling into rubber, paint or vehicles. It can be redispersed in water. In the case of rubber, it confers high modulus, hardness, tear resistance and good tensile strength up to high loadings.

pH in water suspension	10.1
Specific Gravity	2.10
Bulk Density	15 to 16 lb. per cu. ft.
Refractive Index	1.475

HIGH MOLECULAR WEIGHT GLYCOLS

Polyethylene glycols 200, 300 and 400 are mixtures of higher glycols, viscous, light-colored hydroscopic, water soluble liquids. They are used as plasticizers for casein, gelatin, glues, poly-vinyl alcohol and special printing inks, because of their low vapor pressures and moderate hydroscopicities. They can be esterified with dibasic acids to form unusual alkyd-type plasticizing resins. These glycols are available in less than carload quantities. They were developed by Carbide & Carbon Chemicals Corp., New York, N. Y.

STRONG, PRIMARY AMINE

O-Aminodicyclohexyl promises to be of value in reactions where an essentially water-insoluble, strong, primary amine is required. It is available in experimental quantities from Monsanto Chemical Co., St. Louis. It may become useful as an intermediate in chemical synthesis. The physical properties are:

Molecular Weight: 181.19
Appearance: colorless liquid.
Specific gravity: 0.936 at 25°/25° C.
Refractive index: 1.493 at 25° C.
Boiling point: 262.5° C.
Solubility: Only slightly soluble in water. Miscible with alcohols, esters, ketones, benzene, chlorinated aliphatic and aromatic solvents, pine oil, turpentine, vegetable oils, and mineral spirits.

HEATRONIC PLASTIC MOLDING

Another contribution of the chemical engineer to further the war effort is the announcement of Heatronic Molding by Bakelite Corp., Unit of Union Carbide and Carbon Corp. Parts molded of Bakelite thermosetting plastics, such as the phenolics and ureas, can now be produced by this process in a matter of seconds rather than minutes. Thus, radio waves add their part to heat and pressure which have always been required for plastics molding, actually generating an "artificial fever" in the plastic parts which are to be molded.

In effect, the Heatronic molding process utilizes high-frequency heating by generating current in an electrostatic field. A preform or rough shape of the plastic article to be molded is placed between two plates of the heatronic equipment just before it is to be put into the mold. The plates themselves stay cool, but, mysteriously, a rough preformed "pill" of plastic becomes uniformly warm all through as the radio current is generated. Thus, evenly heated throughout its thickness, the plastic preform, transferred to the mold, flows easily into all of the corners and sections to produce a finished, strong plastic part with much less pressure and in much less time.

In addition to the time saved, two other advantages are of extreme importance. First, plastic parts can be molded in thicknesses and sizes hitherto impractical with standard molding methods and conventional equipment. Second, existing molds and molding press equipment may be used to produce plastic parts which, before the introduction of heatronic molding, would have required a long wait for the manufacture of high-pressure presses. Once again the mutual interdependence of plastics and the electronics industry is demonstrated as it probably will be even more so in the years to come.

THE MAGNET

Dings MAGNETIC SEPARATION HIGH INTENSITY

Published by DINGS MAGNETIC SEPARATOR CO., 505 Smith St., Milwaukee, Wis.

Rubbish Plant Reclaims Metal

With ever-increasing metal shortages, the example set at a Milwaukee, Wisconsin, ash and rubbish reclaiming plant several years ago may suggest a profitable idea to many plants with a waste pile containing liberal amounts of magnetic metal. The photograph illustrates the conveyor leading to the incinerator. A Dings Magnetic Pulley removes 18,000 tons of iron annually.

You Can't Smoke Iron!

Maybe removing the iron from "coffin nails" makes them less injurious to the smoker. At any rate, processing machinery must be protected, so many tobacco firms use Dings Separators. Quoting the W. H. Winstead Co., Baltimore, regarding a Dings Type L Magnet on leaf tobacco, "We are getting excellent results."

DE-MAGNETIZER

In many cases where metal is subjected to magnetic influence during processing or handling, residual magnetism presents a problem in succeeding phases of the operations. To overcome this Dings supplies De-magnetizers to suit requirements.

* * *

For additional information on any equipment described here or for details on separators to handle specific problems, address the Dings Magnetic Separator Company, 505 E. Smith St., Milwaukee, Wisconsin.

DRUM TYPE SEPARATORS SOLVE MANY PROBLEMS

THE High Intensity Magnetic Drum affords a completely automatic method of iron-removal at the bottoms of chutes and hoppers, in conjunction with conveyors and in various types of stationary installations.

Magnetic Drums have the advantage, in some installations where fire and dust explosions are a hazard, of having no sliding contacts thus creating no sparks due to arcing. Their ability to discharge iron automatically also constitutes an important feature. In addition, they can be incorporated into housings readily and are thus offered in several standard models.

Operating Principle

Powerful electro-magnetic coils are installed within a revolving cylindrical shell over which material passes. Magnetic materials are held fast to the surface of the shell until they are rotated around to a point outside of the magnetic influence. Here they are discharged.

Agitating Drums

Where closely associated or entangled materials are encountered, Dings Agitating Drums provide an answer to complete separation. An alternate pole magnet plus a special secondary drum provide mechanical disentanglement making possible clean cut magnetic separation. One of many Dings Separators to meet all problems. Details on request. Ask for Catalog 660.

Principle of Operation of Magnetic Drum

Separators Aid in Processing Reclaimed Rubber

In conjunction with the grinding operation in processing reclaimed rubber, many plants are profitably employing Dings Separators of various types. Dings Separators remove all iron and steel such as found in the beads of tires. Completely automatic units which remove and discharge iron have been devised to fit into a variety of handling systems. Latest type is a special, self-contained unit for installation at any desired point. For information concerning separators for this and other similar purposes, outline your problem in a letter to Dings or ask to have a representative call.

"Dinging" It

THAT the name Dings is virtually synonomous with separation in the minds of many, was recently evidenced in an interview with an engineer in a large Eastern plant. In all cases when referring specifically to magnetic separation, he referred to "Dinging" his material to remove the iron. Plan now to "Ding" your materials, too.

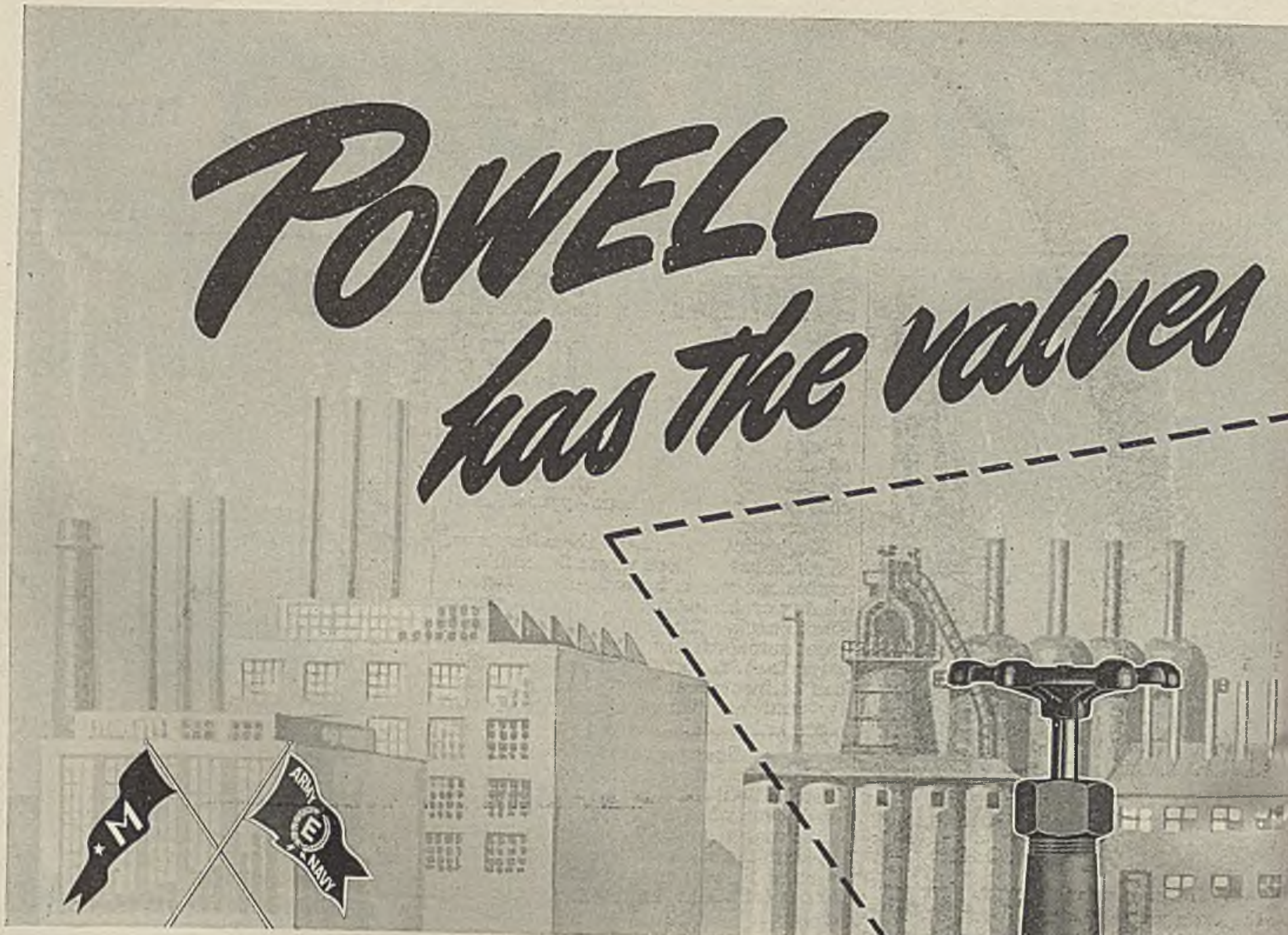
Iron of Abrasion Removed From Cryolite . . . and Gravure Inks

A recent application of the Dings De-Ironer, high intensity wet type separator, is for the removal of iron of abrasion from cryolite pulp. The machine handles approximately 20 gallons per minute. Liquids treated with the De-Ironer pass through a series of grids with hundreds of lineal feet of highly intensified magnetic edges. De-Ironers have bronze bowls, chromium plated stainless steel parts, are extremely simple, have few moving parts, will remove iron particles of micron size. Built in pressure or gravity models.

Another recent De-Ironer application is for removing fine iron from heavy gravure inks. Details on De-Ironers on request.

NEW CATALOG

Dings Double Gap Magnets — spout and suspended type—are fully described in new Catalog 301. Discusses broad range of applications for tramp iron removal to protect equipment, produce iron-free product, prevent fires and explosions. Includes specifications and other data. Available on request.



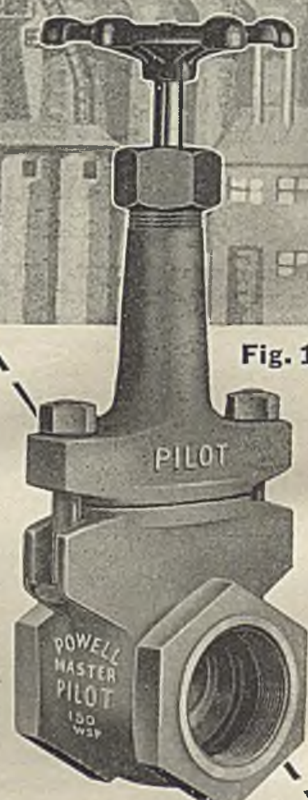


Fig. 1462

From 1846, when Powell started making valves, until the outbreak of the "Global War", the pace of industrial progress was constantly accelerating. One after another, with ever-increasing rapidity, new products and processes were being evolved. And as each became a reality, Powell was ready with the correct valves.

Since Pearl Harbor the rate of acceleration has reached a peak. And—as in the past—Powell Engineering has been meeting every challenge★. Let us help you with any valve problem you may have—Powell has the valve you need—or we'll design one for you.

★For the contribution we are making toward winning this War, we have been honored with the Army-Navy "E", the Maritime "M" and the Victory Fleet Flag.

Fig. 1462—All Iron "Master Pilot" Gate Valve. Screwed ends, rising stem, bolted flanged bonnet, taper wedge solid disc. Sizes ¼" to 2" for 150 pounds W. P.; 2½" to 4" for 125 pounds W. P. Also available in iron body, bronze mounted—Fig. 1460.

The Wm. Powell Company

Dependable Valves Since 1846

Cincinnati, Ohio

POWELL

Fig. 457—All Iron "Model Star" Globe Valve. Flanged ends, outside screw stem, bolted flanged yoke and regrindable, renewable iron disc. Sizes 2″ to 10″, inclusive.

Fig. 171—All Iron "Irenew" Globe Valve for 150 pounds W. P. Screwed ends, union bonnet and regrindable, renewable iron plug type seat and disc. Steel stem.

Fig. 1816—All Iron "Model Star" Gate Valve for 125 pounds W. P. Flanged ends, outside screw rising stem, bolted flanged yoke, taper wedge solid disc. Also available with double disc—Fig. 1453.

VALVES

NEWS FROM ABROAD

INCREASED ACREAGE BRINGS NEW DEMANDS FOR BRITISH FERTILIZER AND INSECTICIDES

Special Correspondence

The extension of the acreage used for agricultural purposes in the British Isles and the change from pasture to arable land, from dairy farming to the growing of bulky vegetables and cereals, which has been carried out progressively during the past three years, has created interesting problems for the British chemical industry which is faced with the task of providing fertilizers, insecticides and other products for agriculture on a vastly increased, and in important respects changed, scale. Some of the questions studied are indicated in a comprehensive official report on agricultural research in Great Britain.

At Rothampstead Experimental Station field experiments are being carried out to determine the agricultural value and the optimal conditions for using (a) new mineral phosphates, mainly Curacao, with special reference to fineness of grinding; (b) phosphatic fertilizers made by newly-developed high-temperature processes; (c) T.V.A. calcium metaphosphate; (d) sewage sludges and town refuses; (e) fertilizers from leather waste; (f) salt for sugar beet and other crops. Experiments with these materials are carried out for Rothampstead at various places in the country.

The Macauley Institute for Soil Research at Aberdeen, Scotland, has been engaged on experiments with peat and other substances used as "conditioners" to prevent fertilizer mixtures from setting hard. Other experiments had the purpose of establishing whether superphosphates could be applied in autumn without loss of efficiency in order to obviate storage difficulties. Other experiments at the Institute were concerned with crushed biotite schist as a source of potash and the value of town refuse as a fertilizer.

Weed control by chemical methods was studied by the Department of Botany of the Imperial College of Science and Technology with a view to reducing the time and labor spent on hand weeding of the onion crop. Sulphuric acid, sodium chlorate and dinitro-ortho-cresol were tried out, and it was found that sodium chlorate in concentrations of 1-3 percent at a rate of application of 100 gallons of solution per acre was unsatisfactory. Dinitro - ortho - cresol sprayed in a 1 percent concentration killed both the weeds and the onions. Sulphuric acid, however, proved singularly effective in destroying the annual weeds without damaging the onion plants when applied in concentration of 9-18 percent and sprayed at the rate of 100-120 gallons per acre.

Experiments undertaken by the laboratory of the Southern Railway with various additions to sodium chlorate in order to increase its action as a weed-killer have shown that salts of manganese, cobalt and nickel, as well as manganese pentoxide, have a favorable effect on the intensity of sodium chlorate solutions. Further tests will be undertaken during the current year.

As far as insecticides are concerned, efforts are made to develop efficient substitutes for lead arsenate, and it is believed that nicotine peat, a combination of nicotine and powdered peat, may prove satisfactory. Preparatory treatment of peat with acids usually improves the combining power and helps to save nicotine because less nicotine can be washed out by rain if the peat is pretreated. Certain hopes are also entertained with regard to rotenone, although preparations containing this substance have been found to decompose rapidly in sunshine. Phenothiazine, synthesized in the laboratory from sulphur and a commercially available dye intermediate, is regarded as promising in the field of insecticides.

The study of minor element deficiency in British soils which aroused a great deal of attention before the war has been found of considerable importance now that soils must be used for the growing of crops which normally would not have been grown on these soils, and it is believed that manganese deficiency can be made good by use of manganese sulphate applied to the soil direct or sprayed in solution on the crop. Deficiency of manganese is reported from various parts of the country, and limited supplies of manganese sulphate have been set aside this year to be issued in suitable cases by War Agricultural Executive Committees on the advise of advisory chemists. Boron and magnesium deficiencies are also causing concern.

The supply of fertilizers is, of course, limited, and in view of the large increase in the arable land under cultivation, strict economy is necessary, especially in the case of such imported fertilizers as phosphates and potash. The basis of allocation is worked out county by county and farm by farm with the assistance of the advisory chemists who are attached to the Provincial Advisory Service of the Ministry of Agriculture. The Sub-Committee in charge of this work has also made recommendations concerning the types of fertilizer mixtures most suitable in wartime conditions for farm and market garden crops.

Dinitro-ortho-cresol has been tried out

as a substitute for tar oils in general-purpose winter washes at the Long Ashton Research Station, and a wash containing 0.1 percent dinitro-ortho-cresol in 5 percent petroleum oil is said to have given almost complete control of capsid bugs in severely affected apple orchards, while it increased the effectiveness of petroleum oils with regard to other insects. Washes for house walls containing a fine proprietary silica dust suspended in water have been found effective in killing insects either as a spray or applied with a brush, and such dusts may prove valuable for the control of insects attacking grain. The Chemical Research Laboratory of the Department of Scientific and Industrial Research has been working in this direction, and it is thought that feldspar and dolomite are probably the most effective dusts at present available which, at the same time, do not apparently involve the risk of silicosis.

Much interest is shown in new feeding stuffs. Successful trials of feeding straw pulp to young cattle are reported from the Midland Agricultural College, and fodder cellulose produced in the manufacture of paper from straw is also eaten by cattle without apparent objection. The National Institute for Research in Dairying is examining the suitability of such special feeding stuffs as (a) caustic soda-treated wheat and barley straw and cavings, (b) detoxified castor bean meal, (c) ammoniated sugar beet pulp, (d) extracted cocoa meal, (e) iodinated proteins. For the latter product in particular a significant increase in milk yield has been observed for cows in declining lactation.

Fumigants for foodstuffs have been studied at the Pest Infestation Laboratory of the Department of Scientific and Industrial Research at Slough. While ethylene oxide is considered most generally suitable, especially when applied with the addition of carbon dioxide, hydrogen cyanide is even more effective, though its properties limit its general use. Methyl formate, carbon bisulphide and certain chlorinated hydrocarbons have also been studied, and the latter promise to be useful for the disinfectation of empty sacks and for the fumigation of small quantities of grain and animal foodstuffs. A basic pyrethrum oil spray for use in warehouses has been standardized, and it is hoped to reduce the pyrethrum content by addition of various adjuvants without affecting the efficiency of the spray.

Hypochlorite disinfectants are reported to have made progress in the agricultural field, and one company which is producing the material in two factories reports that both the main factories were in production throughout the last year. No doubt the improvement in sales of this and other materials is due to special wartime conditions—increased spending power of farmers, encouragement of new developments by advisers and authorities, need for maximum production of foodstuffs, and cutting-down of avoidable losses—but there is no doubt that the recent headway will have far-reaching effects even after the war.

American experience in the field of frosted foodstuffs is likely to be made use of under arrangements between Lever Bros. and Unilever Ltd., the big British margarine interests, and General Foods Corp. of New York. The two companies cooperate in Frosted Foods Ltd., a company which has just raised its capital by £700,000 to £800,000, of which £100,000 "A" ordinary shares go to the New York company in consideration for the sale of certain patents and rights, while the rest is taken up by Lever Bros. and Unilever Ltd. for cash in the form of "B" ordinary shares.

Further examples of growing interest in domestic substances as raw materials for chemical and allied productions came to hand this month. The Department of Textile Industries at Leeds University reports that much progress has been made in the work on the production of various types of seaweed rayon and in the synthesis of new derivatives of alginic acid, its chief component. A Glasgow chemical manufacturer is interested in work now going on for the production of peat briquettes which has also the support of the Scottish Committee for Fuel Efficiency and Economy.

The recently founded British Barytes Producers' Association has been working in collaboration with a government department to insure production of adequate supplies of barytes for British needs. The British Barytes Producers' Association includes in its membership the owners of nearly all the developed mines of known importance in Great Britain. Before the war substantial quantities of barytes used to be imported from the Continent for reasons of quality and cost, but since these supplies have been interrupted, efforts have been made to supply first-class material from British sources, and it is even believed that Great Britain could export first-rate barytes—pure white and finely milled—to American markets.

The increased wartime output of ironstone has given rise to the formation of a National Council of Associated Iron Ore Producers which includes producers of ironstone and iron ore throughout the country and is to consider and advise on all matters affecting the iron ore and ironstone producing industry.

Deliveries of china clay have been in tonnage practically the same as in the previous year, reports of the leading English producers for 1942, although substantial quantities had to be drawn from stock. The company has developed sales of subsidiary products as substitutes for substances previously imported. In the summer of 1942 the Board of Trade instituted a licensing system for the production of China clay, but a most substantial measure of concentration had already been effected by the company among its pits, and negotiations are proceeding with the Government for the creation of a fund to cover cost of care and maintenance of the closed pits, while there is also a voluntary scheme to protect firms whose production facilities have been withdrawn as a result of the licensing system.

HEMISPHERE PRODUCTION OF ANTIMONY INCREASED

With the loss of imports from the Far East, increased production in the Western Hemisphere, particularly in Mexico and Bolivia, is sufficient to cover United States war needs for antimony. In fact, expansion in hemisphere output permits stockpiling as a reserve against future needs. Besides Mexico and Bolivia, there is actual or potential antimony production in Peru, Guatemala, Honduras and Argentina. Two antimony mines in Honduras began operations late in 1941.

While these hemisphere sources now constitute the chief source of antimony available to the United Nations, they produced only 19.6 percent in the peak year of 1929. This jumped to an estimated 62 percent of the world total in 1941, partly because of curtailed mining operations in China, and also because the Americas increased their production. Many hemisphere antimony mines are small and individually operated enterprises. With the ore comparatively near the surface, not much heavy equipment is needed. Some mines are able to produce simply with hand shovels, shipping ore to smelters.

MEXICO HAS LARGE PLANTING OF CINCHONA TREES

Mexico, increasing source of minerals, fibers and other strategic supplies, also may become a larger source of quinine to help replace losses of this vital product in the Netherlands East Indies. An important center of quinine production has developed in the southern state of Chiapas. Mexico has a quinine institute which is encouraging the development of the industry and setting up laboratories to extract sulphate of quinine from cinchona trees.

In two years, according to Mexican press reports, some 170,000 cinchona trees have been planted successfully. Mexican quinine specialists ranged through the principal quinine-producing areas of Asia and the Western Hemisphere in preparation for this development.

In Guatemala, Costa Rica, Peru and other countries to the south, the cinchona industry is being encouraged, with the assurance of a large market. The eastern slopes of the Andes are a natural habitat of the cinchona tree. Favorable growing areas also have been found in the highlands of Middle America extending into the tropical areas of southern Mexico.

SPAIN WILL BUILD NEW CHEMICAL PLANTS

Authorization has been given for the erection in Albacete, Spain, of a potassium permanganate plant, with an annual capacity of 36 metric tons, states a Spanish technical publication.

A plant is to be built in Malaga for the production of sodium fluosilicate; it will have an annual output of 100 tons.

The production, sale, and prices of agricultural insectides recently have been placed under control, by a decree of the Minister of Agriculture.

CANADA PLANS LARGE INCREASE IN FLAX ACREAGE

Canada's 1943 goal for flaxseed cultivation was set at 2,500,000 acres in December, an increase of 68 percent over the 1942 acreage. Later, the Dominion Minister of Agriculture expressed doubt that an increase in flax acreage over 1942 was necessary, and in the announcement to the House of Commons the goal was set tentatively at 1,500,000 acres. Other officials, however, have continued to ask for 2,500,000 acres, and in view of recent good demand in the United States and Great Britain it is likely that the figure of 1,500,000 acres will be revised, and the farmers urged to plant as much flax as possible.

Farmers, many of them growing flax for the first time, were generally well satisfied with the results of the 1942 crop. Yields were good, and the return per acre proved in most cases to be far above that for wheat at 90 cents per bushel. In addition, absence of delivery quotas enabled farmers to realize a cash income from the entire crop immediately after threshing.

BRAZIL USES VEGETABLE OIL FOR DIESEL FUEL

Of the total quantity of edible vegetable oils produced in the State of Sao Paulo, Brazil, some 40,000 metric tons are consumed annually in the country. In 1942, an additional quantity was used for diesel fuel. It is generally understood that the government prohibited the exportation of cottonseed oil last year so as to force its use as a substitute for imported diesel oil.

The cottonseed oil was a satisfactory substitute, and diesel trains used it with excellent results. The chief objection was the price, which was about twice as high as that for regular diesel oil.

Current estimates indicate that the new cotton crop will yield between 650,000 and 750,000 metric tons of cottonseed. The government will take 30,000 to 40,000 tons for next season's planting.

CHROME ORE DEPOSIT FOUND IN MANITOBA

A deposit of chrome ore, discovered in the Bird River district of Manitoba, Canada is reported by the press to be extensive enough to support two plants having a daily production capacity of 1,000 tons of ore. Reportedly, the deposit consists of strong bands that are long and wide but the iron-chrome ratio of the ore is said to be rather heavy.

ITALY IS COMPLETING SECOND SYNTHETIC RUBBER PLANT

Italy's second synthetic rubber factory, being built under the auspices of the Pirelli rubber concern and I. G. Farbenindustrie, is nearing completion, says the European press. Compared with the first Italian factory, the new plant is said to be better equipped and to have a greater production capacity.

DIGESTS OF FOREIGN LITERATURE

REFRACTORIES FROM ZIRCONIUM MINERALS

HIGHLY refractory materials were prepared from three samples of zirconium minerals having differing contents of zirconium oxide, silica and impurities. Data on some of the properties of the three materials used are given in the accompanying table. About 50 percent of the material consisted of particles finer than 0.08 mm., the rest being from 0.08-1.0 mm. This material was pressed into tablets 11x11x6 cm. and cylinders 5x5 cm.

Digest from "Certain Properties of National Zirconium Minerals," by Frederico B. Angeleri, *Anais da Associacao Quimica do Brasil* I, No. 4, 225-233, 1942. (Published in Brazil.)

TEST FOR AMINO ACIDS

To ONE volume of the neutral solution of the amino acid there is added one volume of a neutral 15-20 percent solution of sodium pentachlorophenate, immediately followed by one-half to one volume of neutral 40 percent formaldehyde solution. The presence of an amino acid is indicated by a white precipitate of pentachlorophenol which may be determined gravimetrically, or colorimetrically by converting it to tetrachlorquinone by means of acetic acid. For the quantitative determination only ½ volume of a ½–1 percent solution of the amino acid should be employed.

Digest from "Amino Acids—A New Test," by Antonio Barreto, Revista de Quimica Industrial, 11, 275, 1942. (Published in Brazil.)

IODINE EXTRACTION FROM OIL-WELL BRINES

IODINE has been extracted from oil-well drilling water by means of either starch or kerosene, but these methods involved a number of difficulties. Naphthenic acids present in the water polluted the starch and lowered its capacity for adsorption, interfered with separation of

Properties of Highly Refractory Zirconium Minerals

Samples	1	2					2 Precalcined at 1,450°	5
Conditions of preparation:								
Pressure (kg./sq.cm.)	400	100	200	300	400	500	400	400
Calcination (deg. C.)	1450	450	1550	1550	1550	1550	1450	1450
Linear contraction (%)	3.0	3.0	2.7	2.6	2.4	2.2	2.0	4.4
Apparent sp.gr. (g./cc.)	3.83	3.31	3.42	3.46	3.51	3.56	3.58	3.73
Perosity (% per vol.)	23.9	33.4	31.2	30.6	29.3	28.4	28.4	26.5
Temp. (deg. C.) of initial deformation under pressure of 2 kg./sq.cm.	1580	1470	1480	....	1480	....	1590	1360
Resistence to compression in cold (kg./sq.cm.) (5 x 5 cm. cylindrical pieces)	750	....	....	....	....	....	750	1050

the starch from the water, and caused the formation of stable emulsions of kerosene and water.

Experiments were conducted on extraction of iodine from oil-well brines of the Baku region which contained naphthenic acids, using acitvated carbon instead of starch or kerosene. This process was found to be practicable and far more advantageous than the others. The iodine extracted under actual operating conditions came up to 87 percent, the carbon becoming saturated with 15 percent iodine. The final yield of crude iodine was 66 percent. Naphthenic acids are adsorbed simultaneously with the iodine. Carbon is capable of adsorbing the iodine ion from acid water, and this property was utilized to develop a practical method of adsorption which led to a considerable decrease in consumption of oxidizer.

Iodine was almost completely removed from the carbon by treatment with a 5 percent solution of caustic soda. However, the naphthenic acids were also extracted and presented considerable difficulties since they form a stable viscous emulsion with water. The solution was therefore treated with aluminum sulphate before extraction of the iodine. The iodine was then removed from the purified solution by means of calcium hypochlorite.

Digest from "Adsorption of Iodine from Drilling Water by Means of Activated Carbon," by A. G. Balchikov and Selimov, *Zhurnal Prikladnoi Khimii* 15, No. 4, 228-36, 1942. (Published in Russia.)

VANADIUM PRODUCTION IN MEXICO

This strategic metal, first discovered in 1802 by Andres Manuel del Rio, of the Mexican School of Mines, is now found in at least 32 localities in Mexico. In fact, this country is the second largest producer of this metal on the North American continent, the most productive regions being in the districts of Chihuahua and Coahuila, which border on Arizona, New Mexico and Texas, Guanajuato, Hidalgo, San Luis Potosi and Zacatecas, which are in central Mexico, and Sinaloa on the western coast.

The attached table shows Mexico's production of vanadium from 1927 to 1941. This metal is now worth $2.95 per kg.

Year	Kilograms	Value
1927	1,338	$1,468
1928	2,640	2,904
1929	806	1,193
1930	147,969	450,022
1940	56,962	177,378
1941	598	1,764

Digest from "Vanadium" by Manuel Munoz Lubier, *Boletin de Minas y Petroleo* 13, No. 6, 3-6, 1942. (Published in Mexico.)

CATALYTIC ETHYLATION OF PHENOL

A mixture of 98 g. of phenol and 200 cc. of ethyl alcohol was passed twice over a catalyst mixture of thorium oxide and aluminum oxide at atmospheric pressure, a temperature of 440-460 deg. C. and at a rate of 10-12 drops per minute. The resulting product was treated a number of times with a 10 percent solution of KOH. The product insoluble in the alkali was extracted with ether, washed with water and dried with calcium chloride. The alkali solution was treated with HCl and the resulting layer of phenols extracted with ether, washed with water and dried. Some 40 percent of the resulting product consisted of a material insoluble in alkali, while 60 percent were phenols. The phenols were distilled 11 times, finally giving 51.4 percent ethyl phenol boiling at 200-220 deg. C., 42.3 percent diethyl phenol boiling at 237-247 deg. C., and 6 percent of a product boiling at 250-255 deg. C. Ethylation of phenol finally results in two isomers, approximately 80 percent *o*-ethyl phenol and 20 percent *p*-ethyl phenol.

Digest from "Alkylation of Phenol. I—Ethylation of Phenol," by Z. P. Alexandrova, *Zhurnal Obschei Khimii* XII, No. 9-10, 522-4, 1942. (Published in Russia.)

CURRENT DISPERSION IN GALVANIC BATHS

Although distribution of a metal by electrolytic deposition on a cathode surface depends to a great extent on distribution of current over a cross-section of electrolyte, this factor has rarely been taken into consideration. A new method was therefore developed for determination of current distribution over a given cross-section of electrolyte and on electrodes.

Distribution of current and of metal on the cathode becomes more uniform with increase in the distance between the electrodes. Distribution of current over a cross-section of electrolyte and on the cathode depends on anodic polarization, which is less with a soluble than with an insoluble anode. The effect of anodic polarization on dispersability is thus analogous to the effect of cathodic polarization. The greater the slope of the anodic polarization curve, the greater the dispersability of the bath.

In calculating the dispersion of current in a galvanic bath, the error due to the relief surface of the object should be taken into account. This error is due to deviation of current lines to the adjacent sections of the cathode and it can be corrected, depending on the form of the cathode surface.

Knowledge of these facts and experimental work done in this connection can help considerably in selecting optimum working conditions for plating relief articles with an even layer of metal.

Digest from "Theory of the Dispersion of the Current in a Galvanic Bath," by N. P. Fedotyev and A. I. Evstuchin, *Zhurnal Obschei Khimii* XII, No. 1-2, 12-29, 1942. (Published in Russia.)

ACIDITY OF DECOLORIZING CLAYS

Fuller's earth and other natural decolorizing clays must be treatd with considerable NaOH before they show an alkaline reaction with phenolphthalein. This apparent acidity is due to the clay's property of absorbing hydroxyl radicals from the base rather than to the presence of free acid. In fact, such clays are usually neutral or slightly alkaline. Activated clays, on the other hand, are always definitely acid due to the chemical treatment they undergo. This acidity remains to a certain degree even after washing with water.

Acidity of the clay is important in the treatment of edible oils since it imparts a certain acidity to the oils which may modify their organoleptic properties. This is particularly true when the oil contains traces of soap from previous operations, since these react with the acid of the clay to liberate fatty acids. Excessive acidity can also attack the filter cloths. Relative acidity of clay for treating edible oils should be such that 50 g. of the clay consume not more than 5-10 cc. of N/10 caustic soda.

Decolorizing clays with relatively high acidity are frequently preferred to neutral clays in treatment of mineral oils and commercial fats. The relative acidity of clay for use with commercial fats should be such that 50 g. of the clay consume up to 15 cc. of N/10 caustic soda.

Digest from "Decolorizing Clays and Their Activation" by Yvone E. Stoudze, *Revista Brasileiria de Quimica* XIV, No. 79, 23-28, 1942. (Published in Brazil.)

SOVIET SOURCES OF BROMINE

Of all the known salt lakes of Siberia, the two most promising in their bromine content are the Ebeity and the Kitchi-Karoy. The former is located 120 km. southeast of the city of Omsk and 18 km. from the railway station of Kukharev. The brines of Lake Ebeity contain 0.02-.04 percent bromine, the muds contain about 0.05 percent. Lake Kitchi-Karoy is in the North Kazakhstan territory. It has a surface of 87 sq.km. and a maximum depth of 0.7 m. The analyses of both brines are given in the acompanying tables.

Digest from "Certain New Sources of Bromine," by I. G. Druzhinin, *Zhurnal Prikladnoi Khimii* XV, No. 3, 101-4, 1942. (Published in Russia.)

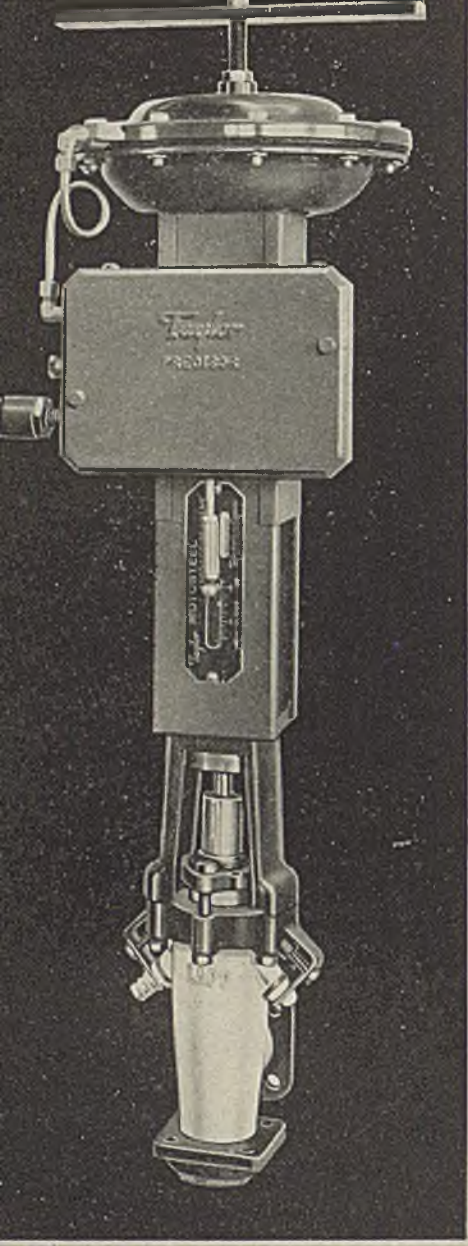
Chemical Composition of Brines from Lake Kitchi-Karoy

Salts	Weight Percent
$Ca(HCO_3)_2$	0.048
$MgSO_4$	6.44
$MgCl_2$	5.21
NaCl	16.85
KCl	0.05
KBr	0.121
B_2O_3	0.007
Dry residue	29.10

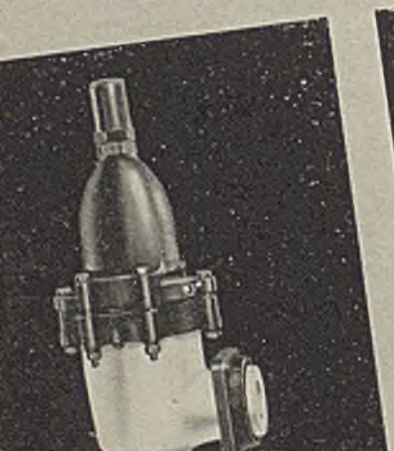
Chemical Composition of Brines from Lake Ebeity

	Percent Salts by Weight						
Sample	$MgSO_4$	Na_2SO_4	$MgCl_2$	KBr	KCl	NaCl	Comments
1	0.48	....	2.35	0.057	0.038	18.98	Winter brines evaporated down
2	2.56	....	....	0.060	0.038	20.35	
3	0.33	....	2.15	0.053	0.021	19.92	
4	1.81	....	17.99	0.46	0.095	3.87	Residual mother liquor after evaporation
5	5.04	1.07	....	0.060	0.038	24.22	Autumn brines
6	6.00	2.13	....	0.057	0.019	22.34	Autumn brines
7	2.86	8.04	....	0.042	0.042	21.75	Summer brines

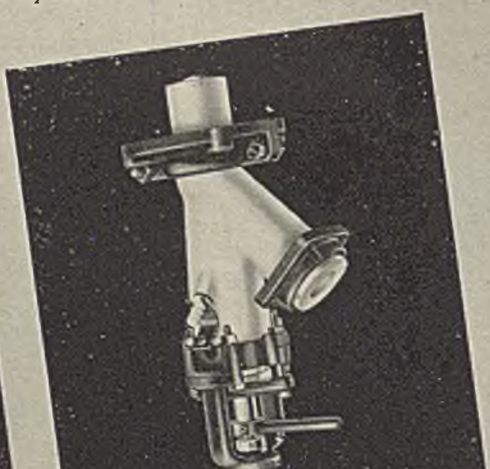
VALVES OF *Chemical Porcelain*



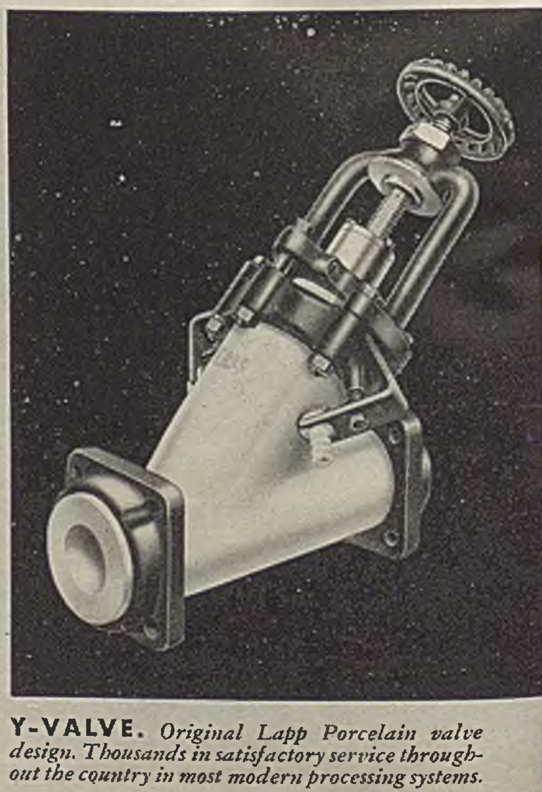
MOTOR-CONTROLLED VALVE. *Adapted to use with control instruments and operated by a diaphragm motor, this Lapp valve facilitates continuous control processing of corrosive liquids.*



POP-TYPE SAFETY VALVE. *Blow-off relief valve, all-porcelain in construction. Quick-positive-opening pop-type.*



FLUSH VALVE. *All-porcelain valve for process kettles—glass-lined, rubber-lined, brick-lined, alloy, lead, etc. Flush poppet eliminates pocket or slug at outlet.*



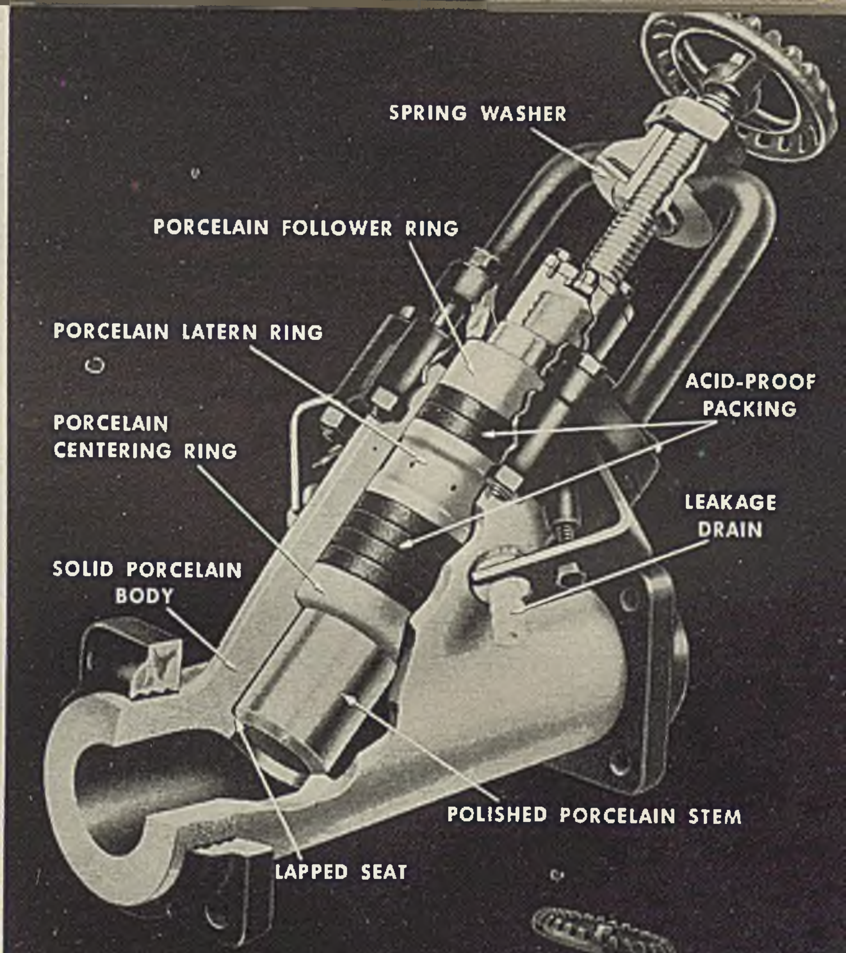
Y-VALVE. *Original Lapp Porcelain valve design. Thousands in satisfactory service throughout the country in most modern processing systems.*

● "Laboratory purity made available to industrial processing." That's the story of Lapp Chemical Porcelain, the material that has been found most satisfactory for handling a wide variety of corrosive chemicals. Physically, Lapp Porcelain is a dense, close-grained, homogeneous material. Glazed or unglazed, it is completely vitrified and non-porous—even under the test of penetrating dye impressed at 100,000 lbs. per sq. in. Neither the glaze nor the body is affected by any acid except hydrofluoric. It is relatively resistant to alkalis. There is no trace of iron in its composition, nor other element which can act as a contaminating agent. Its high mechanical strength and ruggedness have been proved by its ability to stand up under normal use and abuse in a number of plants.

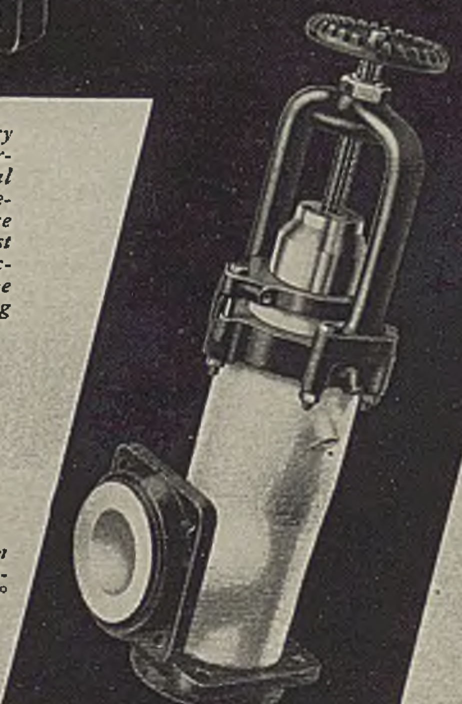
A primary conception in the design of all valves of Lapp Porcelain is that all surfaces exposed to liquid be of solid porcelain. Stems and bearing surfaces are precision lathe-ground, polished and lapped. This assures a tight seal and smooth operation with low packing pressure. A spring washer, compressed as valve is closed, maintains sealing pressure under thermal variation and vibration.

Angle valves, Y-valves and motor-controlled valves are available in ½", 1", 1½", 2", 2½", 3" and 4" sizes; flush valves to fit tank outlets 3", 4" and 5". Standard flanges permit assembly with Lapp Porcelain pipe with thin, hard gaskets—or no gaskets at all.

LAPP INSULATOR CO., INC., CHEMICAL PORCELAIN DIVISION, LeROY, N. Y.



● *The inside story of Lapp valve performance. Chemical security and mechanical excellence make it "the first completely satisfactory answer to the problem of handling many corrosives."*



ANGLE VALVE.
Same construction as Y-valve; interchangeable with 90° elbow in pipe line.

ARMY E NAVY

Lapp

Chemical Porcelain

Valves • Pipe • Raschig Rings

CHEMICAL ENGINEER'S BOOKSHELF

AUTHORITATIVE AND COMPREHENSIVE

ORGANIC CHEMISTRY. An Advanced Treatise, Second Edition, Two Volumes. Edited by *Henry Gilman*. Published by John Wiley & Sons, Inc., New York, N. Y. 3127 pages. Price $7.50 per volume.

Reviewed by *John R. Callaham*

REVISED and enlarged by 12 percent after only five years, the present edition of this advanced treatise retains all the excellent features of the 1938 volumes and establishes without doubt this work as the outstanding publication of its kind in this country. Mr. Gilman and his 30 contributing specialists, having established this graduate-level general treatise of organic chemistry, are now following through by keeping the work up-to-date. In many chapters the data and literature have been reviewed up to September, 1942.

Among the outstanding features of this work, other than its obvious authoritativeness and comprehensiveness. Are direct, lucid style and clarity of presentation throughout. Individual chapters as well as the subject matter within each chapter are logically and well arranged. The index, which is excellent, is duplicated in each volume.

This second edition contains 26 chapters, of which the following eight are new: reactions of aliphatic hydrocarbons, synthetic polymers, catalytic hydrogenation and hydrogenolysis, organic sulphur compounds, aliphatic fluorides, chemistry of the porphyrins, chlorophyll, the redistribution reaction. All chapters carried over from the first edition have been revised.

There is no doubt that this book, more than ever, will prove of tremendous value as a reference to every organic chemist, whether in industrial research, graduate work or in the teaching profession.

GRAPHICAL SOLUTIONS

EMPIRICAL EQUATIONS AND NOMOGRAPHY. By *Dale S. Davis*. Published by McGraw-Hill Book Co., New York, N. Y. 200 pages. Price $2.50.

Reviewed by *L. B. Pope*

TO THE readers of contemporary chemical periodicals the name of D. S. Davis needs no introduction. For more than a decade he has been giving nomograms for routine solution of many chemical and engineering equations. Knowing what the author has done in the way of publishing charts for solution of specific problems will add interest to his treatise giving the "how to." He can give away no trade secrets for there are several books available which cover substantially the same ground. However, Davis, with the aid of completely worked-out examples, probably comes closest to giving understandable directions to readers who are engineers rather than mathematicians.

The book is in two parts, each of which is mentioned in the title. Chapter I of Part I covers the fundamental forms of empirical equations. The desirability of expressing experimental data in the form of an equation is obvious. This chapter gives step-by-step directions for taking results plotted on regular coordinate paper and converting them into one of the 10 types of equations. Chapters II and III of this section cover special methods for two and three-variable correlation.

It is Part II which covers nomography—the theory and construction of alignment and line coordinate charts. All of the various types are discussed: addition charts, logarithmic charts, recurrent variable charts, nonlogarithmetic multiplication charts, combination charts and line coordinate charts. Here again the author has selected a typical example for each type, worked through the calculations necessary for the construction and presented them together with the completed nomograph.

A chapter on the construction of special slide rules will be found of value. A complete bibliography, an appendix containing log tables and tables of trigonometric functions, an index and numerous problems for solution are also included. Checking a few references given with the problems in the second half of the book leads one to suspect that they are answers in the form of finished nomographs.

There probably are some chemical engineers and chemists whose interest in empirical equations has extended only to curiousity as to how they were derived, and whose appreciation of nomographs is only for the ease with which routine calculations may be handled. They might like to find their personal problems solved for them in this book. That, however, will come only with work and understanding. Davis leads the way quite competently.

THEORY AND PRACTICE

METALLURGY OF COPPER. By *Joseph Newton* and *Curtis L. Wilson*. Published by John Wiley & Sons, New York, N. Y. 518 pages. Price $6.

Reviewed by *H. G. Hymer*

THE AUTHORS of this book are to be commended not only in the comprehensive compilation of recent literature on copper metallurgy, but also by the coherent method utilized in presenting the subject as a whole. The theoretical and general explanations of the various processes of smelting and refining are closely followed by detailed, concrete descriptions of both domestic and foreign practices by the leading producers. The pyrometallurgical processes are particularly complete and fully explained, and hydrometallurgy is well covered. Such subjects as smoke and fume treatment are amply discussed.

In addition to the descriptions generally considered as strictly of a metallurgical nature, a comprehensive survey of the industry is provided by the treatment of closely related subjects such as ore concentration, properties, uses, detailed production statistics and specifications of the metal. Also the importance and relation of secondary copper to the industry and a classification of old metal have not been overlooked.

The completeness with which the industry as a whole has been treated and the arrangement of the subject matter should make this book an adequate reference for the student as well as others interested in the copper industry.

MINERAL POLICY

WORLD MINERALS AND WORLD PEACE. By *C. K. Leith*, *J. W. Furness* and *Cleona Lewis*. Published by The Brookings Institution, Washington, D. C. 253 pages. Price $2.50.

Reviewed by *R. S. McBride*

THIS book presents a factual study of mineral supply as it affects international relations. Many will wish that the senior authors, who are among the world's greatest authorities on this subject, had more frequently expressed their interpretations and opinions. In fact, the major fault with the book is that it is much too factual and mild in statement, where often even dramatic interpretations would have been justified. Fortunately, careful reading does disclose much of the judgment of these distinguished mineral economists.

The Brookings Institution in presenting this volume was obviously seeking to lay a factual foundation from which postwar adjustments might more constructively proceed. Chemical process industries which use minerals as raw materials will find much of value in the book to guide industrial planning. One of the outstanding items of this character is the conclusion which introduces Part I of the book, namely:

"The conclusion is reached that although there may be new discoveries and developments, there is not likely to be any great modification in the present geography of mineral production; that no nation can become self-sufficient in minerals; and that there will be no lessening of the interdependence of nations for mineral supplies."

The interdependence of industrial nations with respect to mineral raw materials is strikingly illustrated by the graphic presentation of typical prewar trade movements. The book makes it clear why this complexity has been necessary and why it may be expected to continue. Although far from "free traders," the authors develop soundly the reasons why freedom of movement of minerals throughout the world is necessary and why mere national self-sufficiency is bound to fail for diversified peacetime economy and with respect to military planning. The factual presentation which ranges from the subject of cartels through to more localized problems of control gives adequate guidance for the industrialist who has not educated himself in these particulars.

Part III of the volume relates to "the future." The adoption of "new and more drastic measures" is forecast. But the objective of using mineral supply as a step toward permanent peace is presented. Any chemical engineer or industrial executive who must struggle with postwar planning as it relates to minerals can profitably study this volume.

GOVERNMENT PUBLICATIONS

The following recently issued documents are available at prices indicated from Superintendent of Documents, Government Printing Office, Washington, D. C. In ordering publications noted in this list always give complete title and the issuing office. Remittances should be made by postal money order, express order, coupons, or check. Do not send postage stamps. All publications are in paper cover unless otherwise specified. When no price is indicated, pamphlet is free and should be ordered from Bureau responsible for its issue.

Changes in Import Duties Since 1930. Tariff Commission. Miscellaneous Series, February 1, 1943. Price 25 cents.

Foreign Commerce Yearbook, 1939. Bureau of Foreign and Domestic Commerce unnumbered document. Price $1.00. Clothbound.

Agricultural Statistics, 1942. Department of Agriculture unnumbered document. Price 75 cents.

Day Length and Crop Yields. Department of Agriculture, Miscellaneous Publication No. 507. Price 5 cents.

Phosphate Resources of Florida, by George R. Mansfield. U. S. Geological Survey, Bulletin 934. Price $1.00.

Subsurface Geology and Oil and Gas Resources of Osage County, Oklahoma. Part 10. Burbank and South Burbank Oil Fields. By N. W. Bass and others. U. S. Geological Survey. Bulletin 900-J. Price 60 cents.

Vanadium Deposits of Colorado and Utah, by R. P. Fischer. U. S. Geological Survey Bulletin, 36-P. Price 30 cents.

Subsurface Geology and Oil and Gas Resources of Osage County, Oklahoma. Part 11. Summary of Subsurface Geology with Special Reference to Oil and Gas. By N. W. Bass. U. S. Geological Survey, Bulletin 900-K. Price 45 cents.

Agricultural Insecticide and Fungicide Packages. Bureau of Standards, Simplified Practice Recommendation R41-42. Price 5 cents.

Conservation of Linseed Oil in Paint. by E. F. Hickson. Bureau of Standards, Letter Circular LC-717. Mimeographed.

Military Hygiene and Sanitation. War Department, Army Regulations No. 40-205.

Prevention and Control of Communicable Diseases of Man. War Department, Army Regulations No. 40-210.

Porcelain Enameled Items. Inspectors'

Manual. War Department, unnumbered document. Price 20 cents.

Quantity of Industrial Explosives Manufactured and Sold for Domestic Consumption in the United States in the Calendar Year 1942. Bureau of Mines Mineral Market Report M. M. S. No. 1045. Mimeographed.

The Storage of Coal, by J. F. Barkley. Bureau of Mines, Information Circular, I. C. 7235. Revised and expanded edition of Information Circular I. C. 7211. Pointers on the storage of coal. Mimeographed.

Electrical Transducer Circuit for Use With Capacity Pick-Up Devices, by E. V. Potter. Bureau of Mines, Report of Investigations R. I. 3685. Mimeographed.

Application of Carbon Tetrachloride-Type Fire-Extinguisher Liquid to Burning Magnesium Chips and Magnesium Incendiary Bombs, by S. J. Pearce and others. Bureau of Mines, Report of Investigations R. I. 3686. Mimeographed.

Use of Manganese Alloys for Electrical Condenser Plates, by E. V. Potter and R. W. Huber. Bureau of Mines, Report of Investigations R. I. 3689. Mimeographed.

Thermoelectric Tester for Checking the Composition of Metals, by B. A. Rogers and others. Bureau of Mines, Report of Investigations R. I. 3690. Mimeographed.

Federal Specifications. New or revised specifications which make up Federal Standard Stock Catalog on the following items; Bag Leather, KK-L-151b, Price 5 cents. Paint; Exterior-Primer, Ready-Mixed, White (Undercoat for Wood), TT-P-25, price 5 cents. Enamel; Lusterless, Olive-Drab (Primarily for non-military use), TT-E-514, price 5 cents. Liquid Insecticide (Household), O-I-546, price 5 cents. Paper; General Specifications, UU-P-31a, price 5 cents. Tile; Structural, Clay, Load-Bearing, Wall, SS-T-341a, price 5 cents. Tile; Structural, Clay, Non-Load-Bearing, SS-T-351a, price 5 cents. Motor Fuel, VV-M-564, price 5 cents. Fuel Oil (For Oil Burners), VV-O-326, price 5 cents. Hydrochloric Acid (Muriatic), Technical-Grade, O-A-86, price 5 cents.

Recent Books and Pamphlets

Questions and Answers Regarding Operation Under the Controlled Materials Plan. Published by War Production Board, Washington, D. C. 7 pages. Answers frequently asked questions in connection with the operation of CMP. Based on field surveys.

Dolemites and Limestone of Western Ohio. By *Wilber Stout.* Bulletin 42, published by Geological Survey of Ohio, Ohio State University, Columbus, Ohio. 468 pages. Price $1.50. Gives specific data as to the geology and composition of the dolemites and limestone of Western Ohio. Gives a regional picture of the geology and a detailed study of the chemical composition and of the mineral components in the stone. Does not discuss quarrying methods, manufacturing processes, marketing conditions, etc.

Patents at Work. Published by Alien Property Custodian, Washington, D. C. 25 pages. Prepared to provide American industry with a brief outline of the policies which have been adopted for the administering of some 50,000 patents now held by the Alien Property Custodian.

Washroom and Locker Room Facilities. Published by Policyholders Service Bureau, Metropolitan Life Insurance Co., New York, N. Y. Examines in detail various considerations in enlarging dressing room, washroom and locker room facilities and in reallocating space.

The Airplane and Tomorrow's World. By *Waldemar Kaempffert.* Pamphlet 78, published by Public Affairs Committee, New York, N. Y. 31 pages. Price 10 cents. The Science Editor of the *New York Times* warns against a dangerous conflict between the "international airplane" and "nationalistic ideas."

Plastics. By *L. K. Arnold.* Bulletin 117, published by Engineering Extension Service, Iowa State College, Ames, Iowa. Brief exposition of types, manufacture, uses and properties of plastics.

Hardness. By *D. Landau.* Published by The Nitralloy Corp., New York, N. Y. 105 pages. A critical examination of hardness, dynamic hardness, and an attempt to reduce hardness to dimensional analysis.

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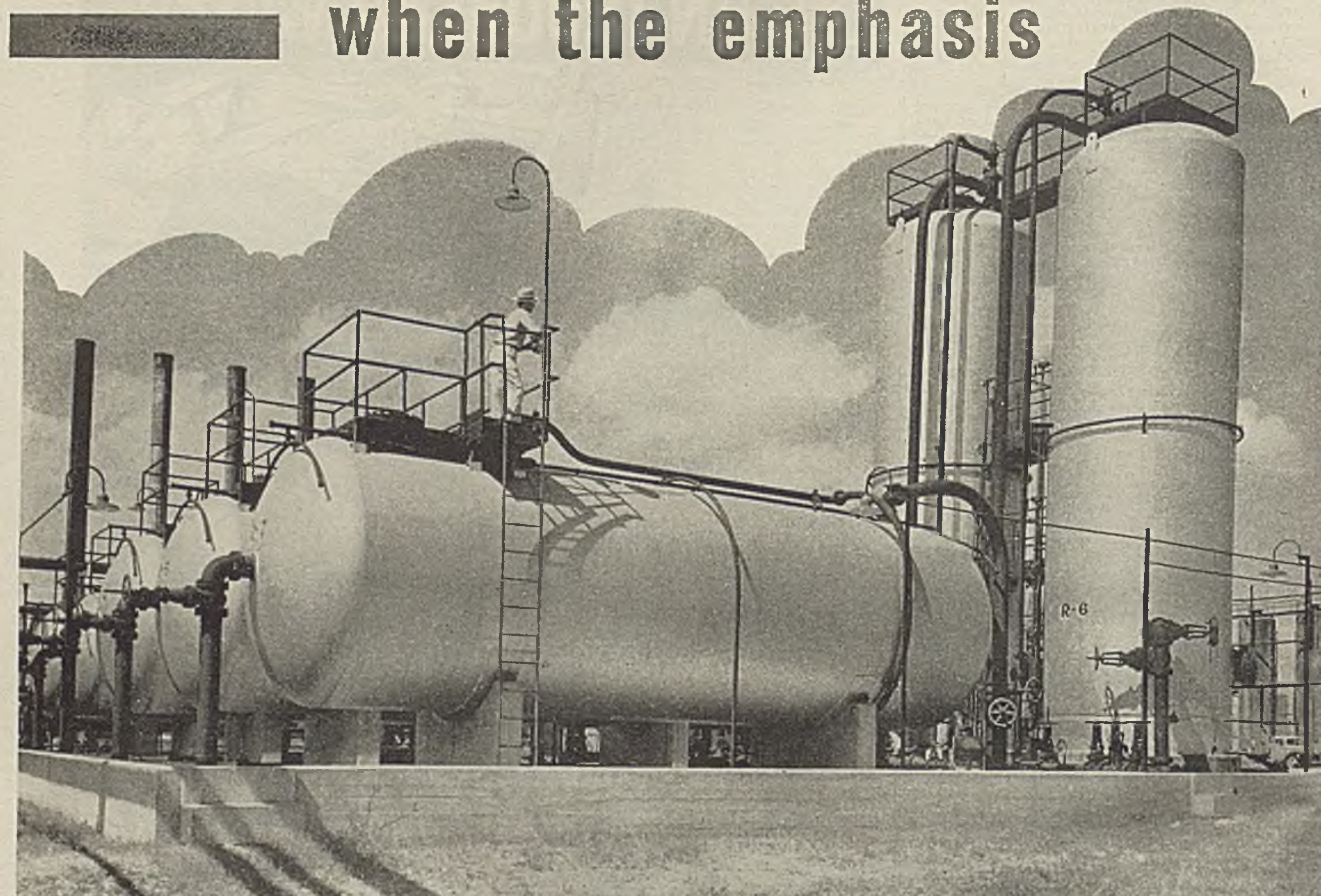
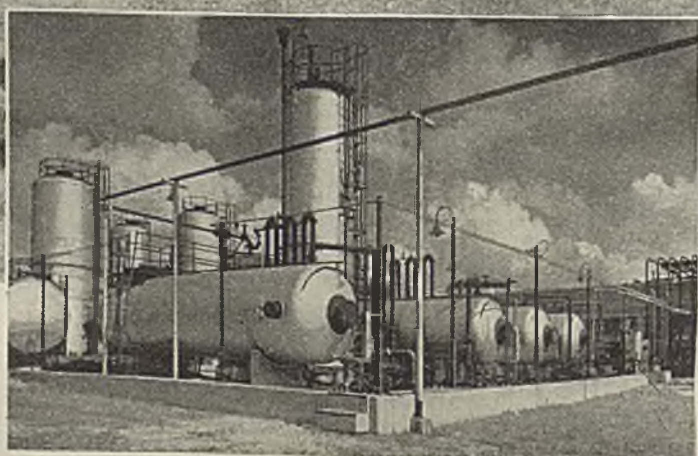
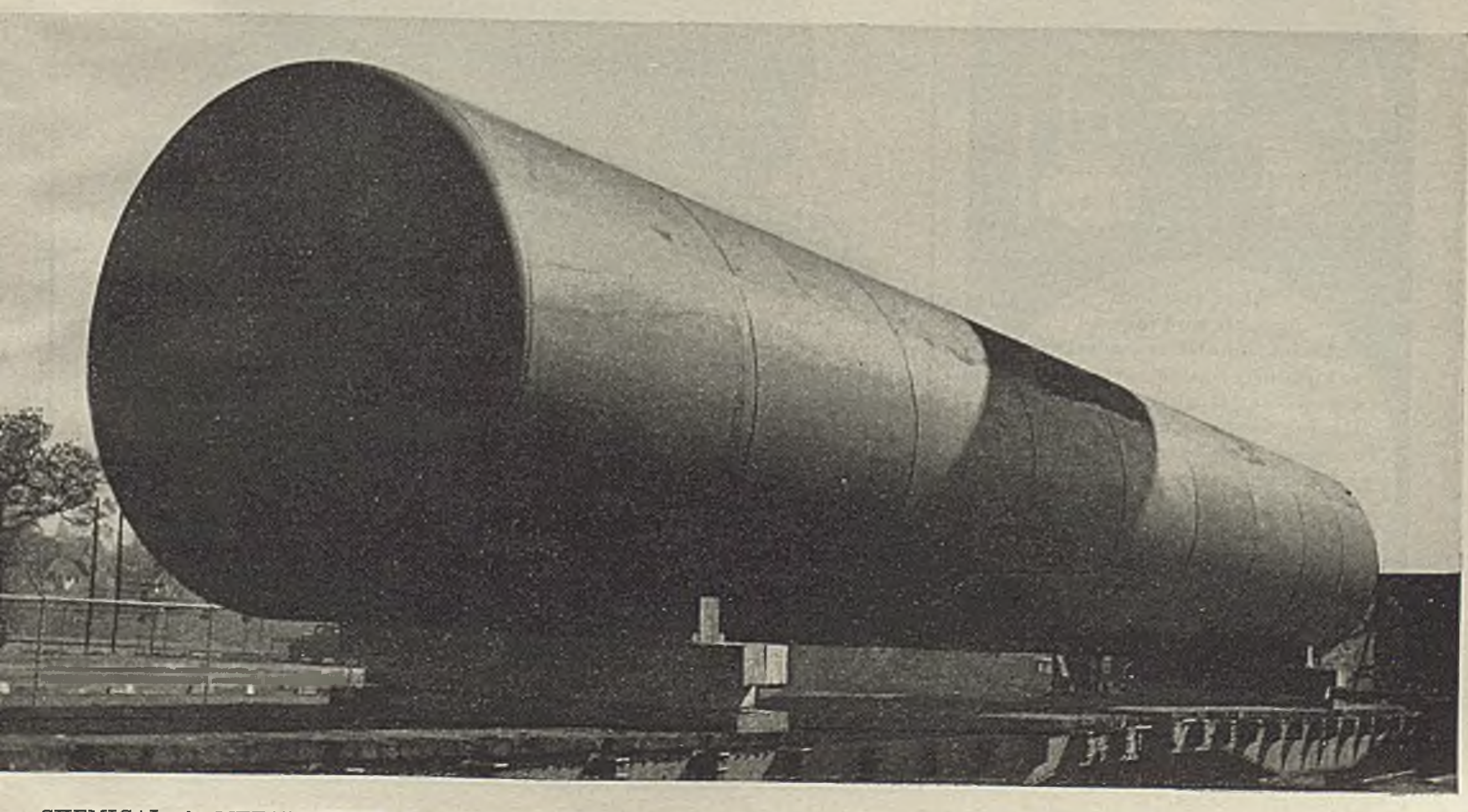




BELOW: *These refinery drums are used in the production of synthetic rubber. They are 10-ft. in diam. by 16-ft. long.*

UPPER LEFT: *Picture shows five 10-ft. diam. by 20-ft. long and two 8-ft. diam. by 30-ft. high pressure vessels in a gasoline treating unit at an oil refinery.* **DIRECTLY ABOVE:** *4 horizontal vessels and a tower each measuring 8-ft. in diam. by 28 ft. in a polymer gasoline treating plant at the same refinery.*

RIGHT: *Welded pressure vessel being shipped from Birmingham plant for wartime service.*



MANUFACTURERS' LATEST PUBLICATIONS

Publications listed here are available from the manufacturers themselves, without cost unless a price is specifically mentioned. To limit the circulation of their literature to responsible engineers, production men and industrial executives, manufacturers usually specify that requests be made on business letterhead.

Adhesives. Paisley Products, Inc., 630 West 51st St., New York, N. Y.—4-page sheet announcing this concern's new waterproof adhesives for war shipments. Contains a list of typical applications.

Automatic Control. Askania Regulator Co., 1603 So. Michigan Ave., Chicago, Ill. —Bulletin 118—4-page folder illustrating and describing the hydraulic jet type principle of automatic control. Gives advantages and functions of the jet type.

Aviation Gasoline Equipment. General Electric Co., Schenectady, N. Y.—Bulletin GES-3147—50-page, spiral-bound notebook giving information on this concern's line of electric equipment for aviation gasoline refinery plants. Discusses power generation, distribution and utilization, including turbine generators, switchgear, load-center unit substations, cable, and many types of motors, controls and cycle timers. Each unit is illustrated and discussed briefly. Extensively illustrated.

Belt Drives. Manheim Mfg. & Belting Co., Manheim, Pa.—8-page catalog on this concern's new "Velos" V-belt. Discusses advantages, industrial application, construction and installation procedures. Also includes data on dimensions, shipping weight, price list and drive rating. Illustrated.

Blowers and Exhausters. Roots & Connersville Blower Corp., Connersville, Ind. —Bulletin 120B12—20-page bulletin dealing with this concern's line of centrifugal blowers and exhausters. Deals with advantages, operating characteristics, construction of single-stage units, centrifugal impellers, construction of multi-stage units, regulation, etc. Extensively illustrated.

Boiler Cleaning. Water Service Laboratories, Inc., 423 W. 126th St., New York, N. Y.—4-page form illustrating and discussing very briefly this concern's "Boil-Out" boiler cleaning service for internal cleaning of heating boilers.

Carbon in Buna S. Columbian Carbon Co., Research Laboratories, 214-44th St., Brooklyn, N. Y.—Vol. 4—152-page booklet entitled "The Carbon Reinforcement of Buna S (GR-S)." Deals with the effects of carbon surface and loading on physical properties of Buna S, batch size and mixing on cure and physical properties, effect of mixing and rest variation, effect of high and low volatile carbons, flex crack growths, etc. Gives detailed data in the form of charts, graphs, sketches and text. Contains extensive experimental data.

Catalyst Recovery. Western Precipitation Corp., 1013 W. 9th St., Los Angeles, Cal.—Booklet dealing with this concern's method of catalyst recovery in aviation gasoline and synthetic rubber plants. Discusses important phases of catalyst recovery, type of equipment best suited to each phase, and method of operation.

Cleaner. National Graphite Co., Inc., 17 John St., New York, N. Y.—1-page form announcing this concern's new "Konag" castor cleaner for degreasing and cleaning metal parts and metal surfaces as well as concrete, painted or tile surfaces, etc. Includes data on prices.

Controllers. The Bristol Co., Waterbury, Conn.—Bulletin A112—8-page bulletin describing a line of new convertible, three-vane, air-operated controllers. Includes data on the five types of controllers along with information on converting from one type to another.

Control Instruments. Zenith Electric Co., 152 West Walton St., Chicago, Ill.—8-page bulletin on this concern's transfer switches, remote control switches, magnetic contactors, reversing starters, and other automatic control equipment. Each unit is illustrated. Contains list prices.

Cooling Towers. The Marley Co., Inc., Kansas City, Kan.—Bulletin 603—20-page booklet illustrating and describing briefly the Marley line of induced draft cooling towers. Extensively illustrated by cross sectioned drawings, diagrams, and installation photographs.

Die Castings. The New Jersey Zinc Co., 160 Front St., New York, N. Y.—Booklet designed to answer questions most often asked about zinc alloy die castings. Contains extensive information on composition and limits, comparison of zinc with other die casting alloys, shape and size limitations, uses, etc. Well illustrated.

Dust Collectors. Thermix Engineering Co., First National Bank Building, Greenwich, Conn.—4-page form dealing with this concern's new ceramic dust collector made entirely of non-critical materials. Describes operating principles, application, construction, and design assembly. Illustrated.

Dynamite Coupler. E. I. DuPont de Nemours & Co., Inc., Explosives Dept., Wilmington, Del.—8-page booklet announcing this concern's new fast coupler device for joining dynamite cartridges for seismic prospecting for oil. Describes briefly the coupler, how it works, and its advantages. Extensively illustrated.

Electric Heat. General Electric Co., Schenectady, N. Y.—Form GES 3130—8-page form illustrating and discussing applications of electric heat in industry. Extensively illustrated with photographic reproductions.

Electronic Equipment. Electron Equipment Corp., Palm Springs, Calif.—Bulletin 170—4-page form illustrating and describing briefly the line of rectifiers, r.p.m. controls, converters, inverters and cycle changers put out by this concern.

Electric Tool Maintenance. Independent Pneumatic Tool Co., 600 W. Jackson Boulevard, Chicago, Ill.—Bulletin JE-199. —20-page booklet and manual dealing with maintenance and proper operation of portable electric tools of all types. Gives information on what to do when a tool fails to operate.

Electronic Contactors. General Electric Co., Schenectady, N. Y.—GEA3058B—8-page booklet dealing with Ignitron contactors for A-C resistance welding. Outlines desirable features of these electronic contactors, describes and illustrates their construction and operation, and illustrates the 150-, the 300-, and the 1,200-ampere sizes. Extensively illustrated.

Equipment. Heat & Power Co., Inc., 45 Bond St., New York, N. Y.—Folder illustrating, listing and describing very briefly the machinery and equipment formerly owned by Vulcanite Portland Cement Co. which is now for sale. Includes kilns, pulverizers, crushers, conveyors, dryers, mills, boiler plants, dust collecting systems, etc.

Filter Papers. Carl Schleicher & Schuell Co., 116-118 W. 14th St., New York, N. Y. —15-page booklet containing reference tables for filtration and methods of chemical analysis. Lists the type of filter paper, both qualitative and quantitative, and use of pulp for various compounds filtered. Compounds are listed under the elements.

Fire Extinguishers. American-La-France-Foamite Corp., Elmira, N. Y.—New booklet entitled "Maintenance of First Aid Fire-Fighting Equipment" which deals with vaporizing liquid, soda-acid, foam, anti-freeze, and carbon dioxide type extinguishers. Includes charts giving data in condensed form as to extinguisher and engine characteristics, methods of operation, capacity, range of stream, etc. Discusses inspection, upkeep, charging, discharging, and recharging. Illustrated.

Floor Gratings. Borden Metal Products Co., Elizabeth, N. J.—8-page pamphlet dealing with the line of floor gratings and safety steps put out by this concern for industrial purposes. Contains information on specifications, load capacities and numerous installation photographs and cross sectional drawings and sketches.

Gages. Trimount Instrument Co., 37 West Van Buren St., Chicago, Ill.—Bulletin 40—4-page form dealing with this concern's liquid level gages. Contains a chart giving models and sizes, together with installation photographs.

Graphite. Acheson Colloids Corp., Port Huron, Mich.—Bulletin 430—12-page booklet on this concern's line of colloidal graphite and its use in various industries. Illustrated. Also bulletin 421, 4-page form dealing with "Dag" colloidal graphite for assembling and running-in engines and machinery.

Heat Exchangers. Downingtown Iron Works, Downingtown, Pa.—4-page form dealing with this concern's new line of "Shellfin" heat exchangers. Describes and illustrates diagrammatically principles of the exchangers and multiple installation. Contains data on dimensions.

Heat Treatment. J. O. Ross Engineering Corp., 350 Madison Ave., New York, N. Y.—4-page pamphlet listing bulletins and literature put out by this concern concerning basic principles, modern methods and equipment for industrial heating, drying, baking, heat treating, normalizing, etc.

High-Temperature Fans. Despatch Oven Co., Minneapolis, Minn.—Bulletin 78—12-page catalog discussing, illustrating and giving data on this concern's line of heavy duty high-temperature fans. Discusses construction features, performance, installation and maintenance, dimensions, standard specifications, and gives extensive capacity tables and conversion charts.

Metal Brazing. Handy & Harmon, 82 Fulton St., New York, N. Y.—Bulletin 12A—18-page illustrated booklet dealing with low temperature brazing of metals with this concerns "Sil-Fos" and "Easy-Flo." Discusses advantages, applications, method of heating, etc. Profusely illustrated.

Motor Controls. General Electric Co., Schenectady, N. Y.—Bulletin GEA 4015—16-page simplified guide to the selection and application of commonly used motor controls. Lists standard controls and describes operation, discusses when to use magnetic and manual controls, explains when reduced-voltage starting is necessary. Well illustrated by photographic reproductions and line drawings.

Nickel Alloys. The International Nickel Co., Inc., 67 Wall St., New York, N. Y.—16-page booklet presenting data on the eight "Inco" high-nickel alloys and their corrosion resistant uses in chemical process industries. Includes data on characteristics of the metals, average mechanical properties, physical constants and other pertinent data. Extensively illustrated.

Nitriting. Leeds & Northrup Co., 4907 Stenton Ave., Philadelphia, Pa.—Catalog T624—18-page catalog on this concern's "Homo" method for nitriting. Discusses methods, advantages of the "Homo" process, installation and furnace equipment. Well illustrated.

Plastic Tubing. Bozell & Jacobs, Inc., 1010 Hearst Square Building, Chicago, Ill.—6-page circular on this concern's line of tubing and fittings of plastic materials. Describes uses in various fields and gives detailed data and physical properties, including charts and tables of working pressures. Illustrated.

Pneumatic Controls. Leeds & Northrup Co., 4907 Stenton Ave., Philadelphia, Pa.—Catalog NOOB—16-page catalog dealing with this concern's line of "Micromax" pneumatic controls for regulation of pH, conductivity and other conditions as well as temperature. Gives standard ranges, dimensions, shipping weights. Extensively illustrated.

Polyvinyl Acetate. Electrochemical Department, E. I. DuPont de Nemours & Co., Wilmington, Del.—Bulletin 4243—New bulletin entitled "Polyvinyl Acetate: Solid, Solution and Emulsion Form," which describes properties and applications of these three forms of the plastic. Illustrated.

Process Equipment. Edge Moor Iron Works, Edgemoor, Del.—12-page form dealing with this concern's line of standard or special design process equipment, such as mixers, kettles, blenders, autoclaves, storage tanks of stainless steel, monel metal and carbon steel. Each unit is illustrated and discussed briefly. Contains data on capacities and dimensions.

Pumps. Worthington Pump & Machinery Corp., Harrison, N. J.—6-page form dealing with this concern's line of vertically-split, single and two-stage volute centrifugal pumps for moderate pressures and temperatures in polymerization, topping, cracking, alkylation and natural gasoline plants. Illustrated. Also 12-page catalog dealing with the Worthington type CC diesel engine of the direct injection, totally enclosed vertical four-cycle type. Contains numerous installation photographs.

Reconditioning Pump Shafts. International Nickel Co., Inc., 67 Wall St., New York, N. Y.—8-page form dealing with methods of reconditioning worn pump shafts and rods by machining and refinishing, by welding, by metal spraying, or by electroplating. Gives suggestions for operating pumps to prolong life of rods and shafts. Extensively illustrated.

Synthetic Resins. The Dow Chemical Co., Midland, Mich.—22-page catalog listing the properties and fabrication techniques for this concern's "Styraloy 22", a new synthetic thermoplastic resin of the hydrocarbon type possessing good low temperature flexibility, electrical properties, and stability to corona discharge at elevated temperatures. Includes data on physical forms, fabrication, mechanical and electrical properties, specifications and heat resistance. Extensively illustrated by drawings, charts and graphs. Contains extensive engineering data.

Synthetic Rubber Softeners. Wishnick-Tumpeer, Inc., 295 Madison Ave., New York, N. Y.—Report summarizing results of tests on the effect of some of the most commonly used softeners on physical properties of Buna-S. Softeners include asphalt, coal tar, and natural tar. Data were obtained on plasticizing action, hardness, tensile strength before and after aging, etc. Results summarized in tabular and graphic form.

Tank Calculator. Buffalo Tank Corp., 19 Rector St., New York, N. Y.—Cardboard tank calculator issued for designers and users of A.S.M.E. code pressure vessels. Sturdily built and easy to operate.

Tank Linings. The United States Stoneware Co., 60 East 42nd St., New York, N. Y.—Bulletin 1502—8-page booklet illustrating and describing briefly the use of this concern's "Resilon" corrosion-resistant tank linings. Includes data on physical and chemical characteristics and applications in various industries.

Temperature Control Cabinet. Precision Scientific Co., 1750 No. Springfield Ave., Chicago, Ill.—Catalog 325—50-page catalog discussing this concern's line of electric heat automatically-controlled temperature control cabinets. Includes data on general specifications, methods of heat transfer, general purpose ovens, cabinets for specific uses, hazard-safe cabinets, incubators, special-built equipment, and dial thermometers. Contains data on specifications.

Thermoswitches. Fenwal, Inc., 80 Main St., Ashland, Mass.—8-page publication entitled "Selection and Application of Thermoswitches" which deals with sensitivity, differential, lag and overshoot, heat balance, heat gradients and thermal conductivity. Includes charts and explanatory copy and shows principles of thermal control, particularly for those just entering the field.

Vitamins. Vitamins Industrial, 222 No. Bank Drive, Chicago, Ill.—14-page catalog released by this company entitled "Vitamin Protection Means Production and Profit" which describes the importance and application of vitamins to industrial workers to increase production, lower absenteeism, etc. Describes the advantages of "Vi⁰" multi-vitamin tablets for combatting nutritional deficiencies and building up industrial employees to maximum efficiency. Includes a chart of the vitamins and minimum daily requirements. Well organized.

Water Treatment. W. H. & L. D. Betz, Gillingham and Worth Sts., Frankfort, Philadelphia, Pa.—Technical paper 82—4-page reprint entitled "New Water Developments and Wartime Economy." Deals with quality of process water required for manufacture of different grades of paper, treatment methods for specific manufacturing uses, analytical plant control for high presure boilers, etc.

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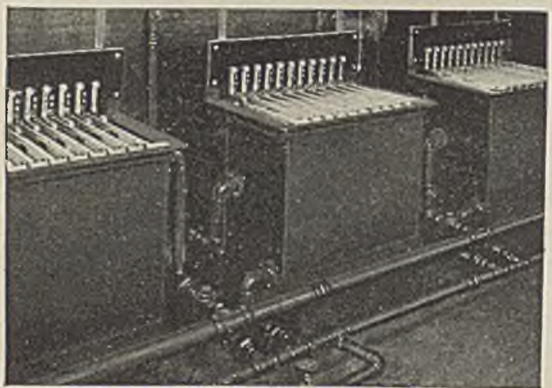
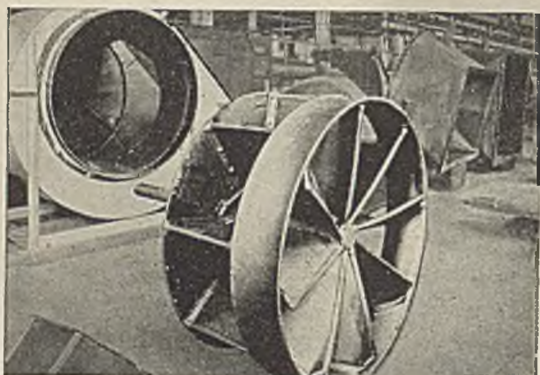
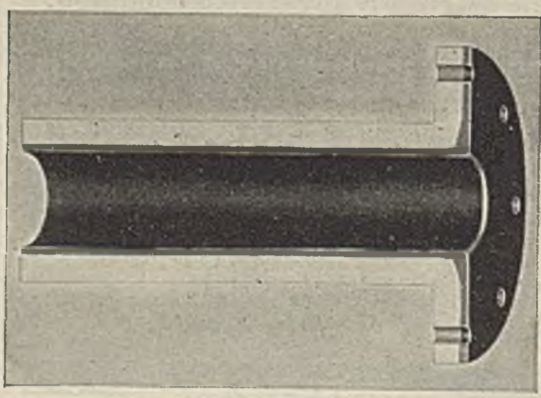
Are you under fire by that old enemy, corrosion? Is he attacking your equipment. . . slowing vital high-priority production . . . eating up profit? Then call on Ace Rubber, with its exclusive properties, to give you positive security against corrosion and contamination.



TANKS Ace Rubber lined and covered steel tanks connected with Ace Hard Rubber pipe and fittings.



BLOWERS Ace Hard Rubber lined and covered for protection against acid-fume corrosion.



ACE RUBBER LINED STEEL PIPE Sizes 2" up. New lining technique for pipe, fittings and valves reduces restriction to a minimum.

WIN the war against corrosion. Arm your equipment with Ace Rubber and avoid costly, time-consuming replacements. Ace Rubber stands off corrosion and contamination . . . is fully resistant to almost all active solutions that eat away and eventually destroy most metals. As lining in tanks, pipe fittings, valves, utensils and other equipment, Ace Rubber will save you money, time, yes, grey hair.

Ace Rubber is smooth, tough, non-porous, easy to keep clean. Case histories, some dating back a half-century, attest to the remarkable corrosive-resistant service rendered by Ace installations. Our engineering and research staffs stand ready to help you, too, without obligation.

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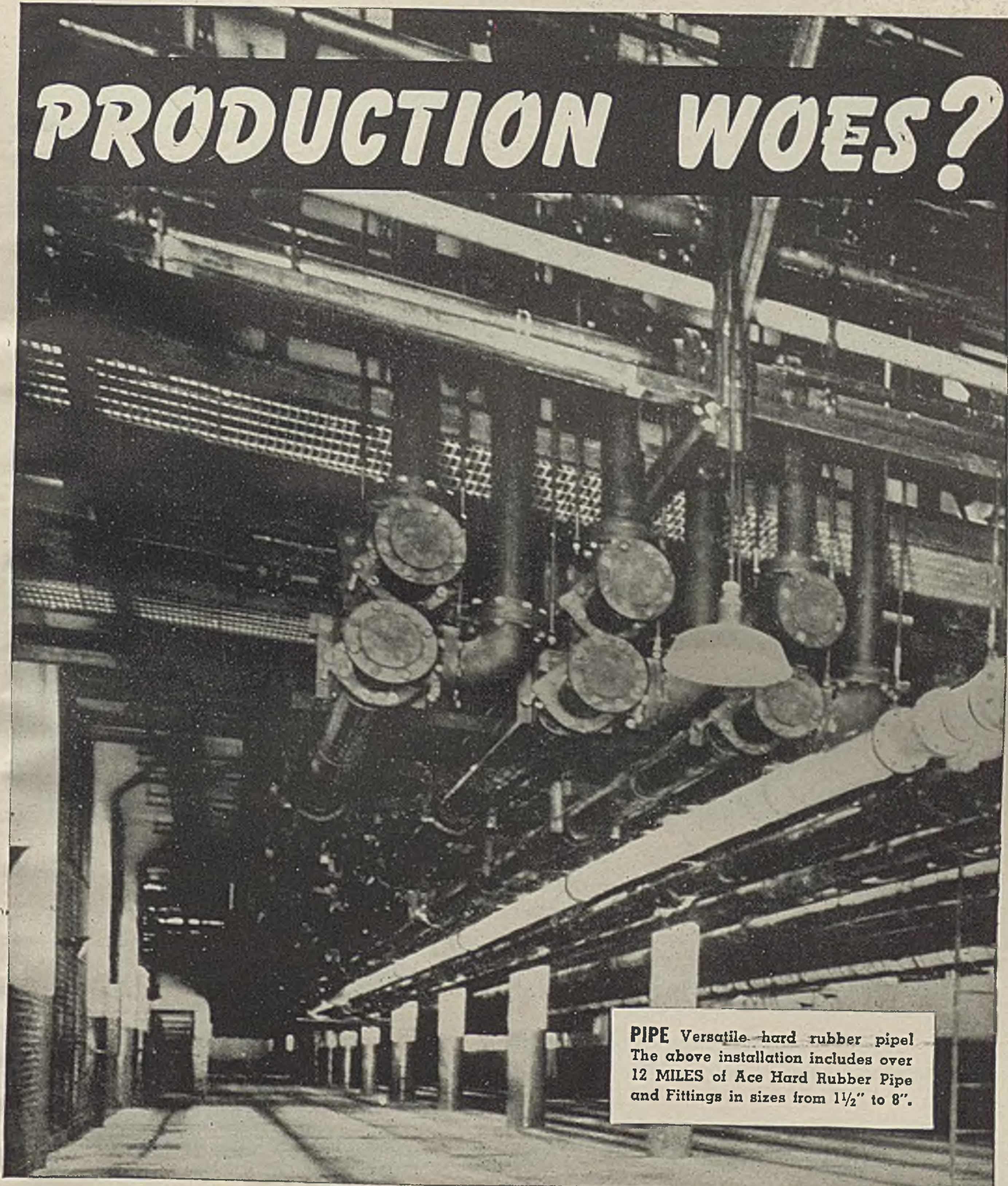
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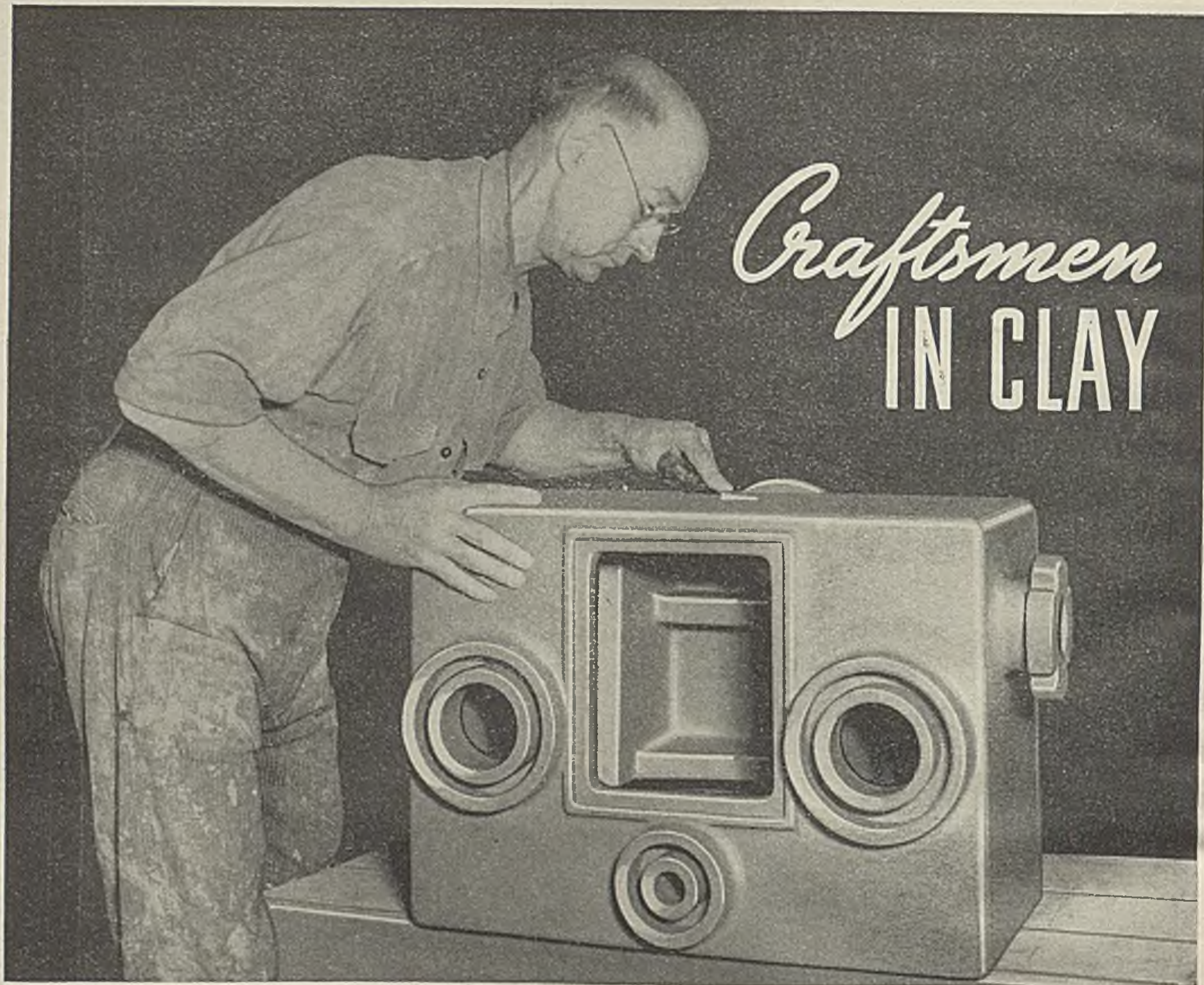
PIPE Versatile hard rubber pipe! The above installation includes over 12 MILES of Ace Hard Rubber Pipe and Fittings in sizes from 1½" to 8".



SPECIAL designs in acid-proof chemical stoneware require more than selected raw materials careful forming and controlled processing. An intricately baffled box or an unusually large tank made in one integral piece without seams or joints, takes plenty of experience and skill to form.

The craftsman's touch shows in Knight handbuilt equipment made to the customer's specifications. Over 35 years of first-hand experience in design, materials and processing plus the work of these "craftsmen in clay" brings you KNIGHT-WARE quality chemical equipment.

Complete resistance to chemical corrosion is an inherent quality of KNIGHT-WARE. "It is the body itself," not a glaze or a coating that is acid-proof.

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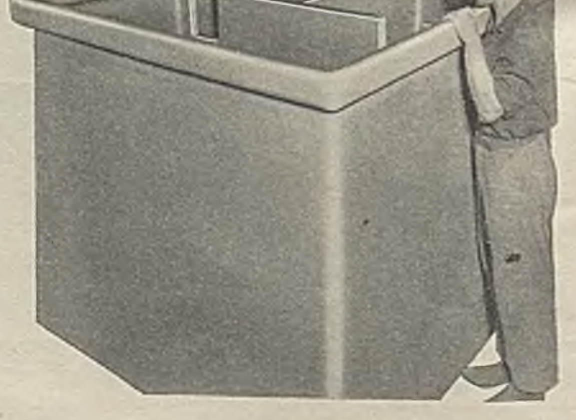
KNIGHT-WARE CHEMICAL EQUIPMENT

In addition to countless items of special design, Knight-Ware chemical equipment can be had in standard items such as valves, piping, fittings, acid jars, kettles, coils, filters and towers.



ECONOMICS AND MARKETS

INDUSTRIAL CONSUMPTION OF CHEMICALS VERY MUCH IN LINE WITH THAT OF LAST YEAR

OVER-ALL consumption of chemicals in the principal industrial lines is maintaining a fairly stable rate as shown by a review of statistics for the first quarter of the year. From the data now available, there appears to have been practically no difference in activities in the first three months of 1942 and 1943. The *Chem. & Met.* indexes for consumption of chemicals in 1942 were: January 177.12, February 162.84, and March 176.38. For the current year the indexes are: January 173.20, February 166.41 (revised), and March 179.93. While the grand totals are but little changed, the contributing components show varying changes from their positions of a year ago. Fertilizer, glass, steel, and rayon plants report enlarged outputs for the current year while reduced activities are reported for pulp and paper, oil refineries, and paint mills. Production of sulphate of ammonia varied but little in the two periods the total for Jan.-March this year was 378,081,555 lb. as against 378,723,368 lb. in the like 1942 period. A similar condition is found in the outputs of ammonia liquor at byproduct coke plants as production was almost identical in the two quarters. Consumption of rubber cannot be definitely placed but it can be said that use of crude has been cut down and use of reclaimed has been enlarged.

It is generally held that the peak point of production has not yet been reached but will come later in the year when most of the plants which figure in the varied military program will come into production and thus increase the demand for raw materials. This would seem to be a logical view if the building program had been carried out according to original schedule. But the stoppage of work on some of the proposed butadiene plants and the cut in the synthetic rubber plans may defer the time for maximum demand for materials if later on it is decided to carry out the original program. In other words, it is not clear whether the present curtailment in plans is permanent or merely represents a postponement of the original program until such times as it can be carried to completion.

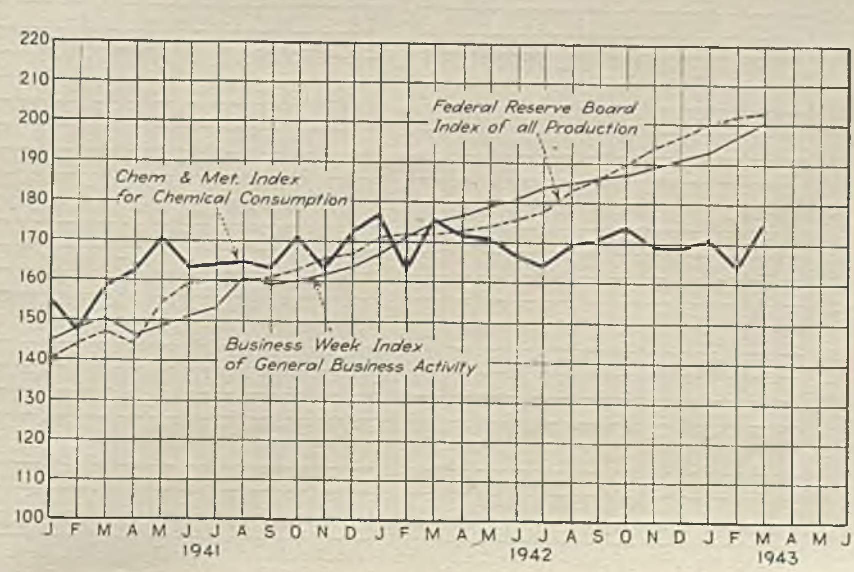
Publication of data for sulphur production and shipments has given rise to some speculation regarding the position of sulphuric acid. Production of sulphur in the first quarter of the year was 664,611 long tons and shipments from mines were 581,753 long tons. These compare with 837,989 long tons and 724,863 long tons respectively for the corresponding period of last year. The drop in mine shipments of sulphur has no bearing on production of acid because acid plants have been accumulating stocks of sulphur in recent years and added materially to such stocks last year when the shipping situation made it appear that stockpiling would be a good move. Now that transportation difficulties have increased the accumulated stocks are being drawn upon at acid plants. However, there has been some drop in acid output recently partly because of labor shortage and partly because the use of the acid had been cut down at some munition plants.

In connection with renegotiating government contracts many companies are interested in establishing the percentage of their industry's business which enters into war production. WPB in reporting on the monthly distribution of chemicals for April stated that the value of such chemicals under allocation was approximately $131,000,000 of which over 47 percent entered into identifiable military production. The report for March placed the percent of distribution which entered identifiable military production at 42 and further stated that many derivative products of the 58 per cent not identified as direct military are necessary for the production of military items. An additional 24 percent of allocated materials went into uses which can be identified as directly related to direct military uses. Therefore the report credits 66 percent of the allocated material as destined for military or indirect military use and adds that this does not include military purchases of chemicals not under allocation. The president of the National Paint, Varnish and Lacquer Association, last month issued a statement to the effect that 75 percent of the production of the paint industry is now being used for military purposes. Therefore it is evident that so far as the chemical and related industries are concerned a very large percent of total output is destined for war purposes. It is very difficult, however, to apportion chemicals according to end use. For instance, production of superphosphate has been taking record amounts of sulphuric acid. A part of this superphosphate will be used to raise foodstuffs for our armed forces. Output of glass in March, largely because of container production, required a record amount of soda ash in its manufacture. It will take intimate knowledge of military requirements of foodstuffs and glass to allocate the part of this sulphuric acid and soda ash which is being used for military purposes.

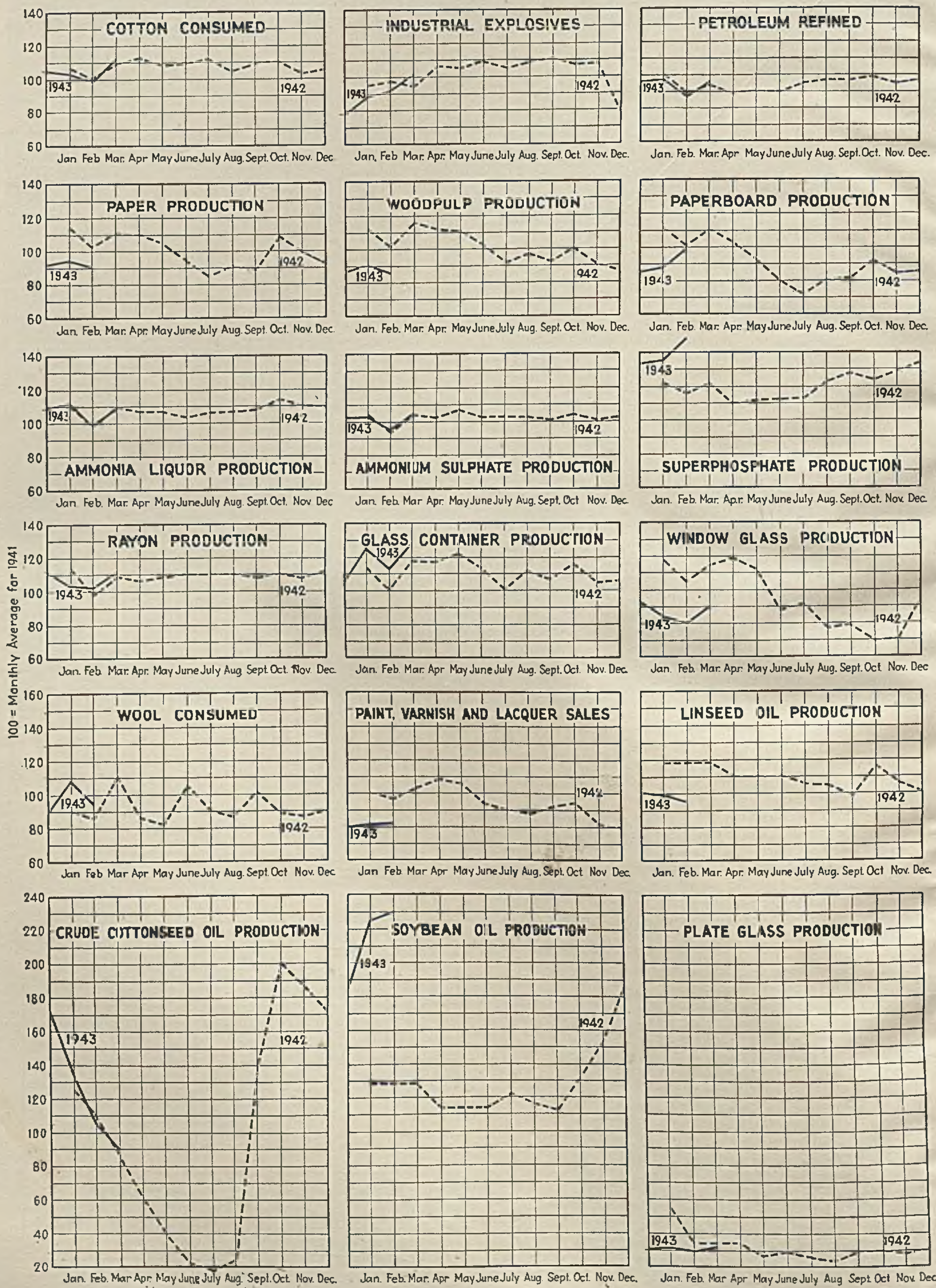
Early in the month, the Office of War Information put out a release to show the great differences between this war and the last one. The purpose of the release was to explain why civilian supplies of many materials had to be curtailed. However, it served equally as well to emphasize why the demand for chemicals and other raw materials was so much larger in the present conflict. For instance, it cited that a mechanized division burns up 18,000 gallons of gasoline an hour proceeding at normal speed; a heavy bomber at cruising speed uses 200 gallons of gasoline and a fighter plane needs 100 gallons an hour.

Chem. & Met. Index for Industrial Consumption of Chemicals

	Feb. revised	March
Fertilizers	41.53	41.15
Pulp and paper	18.75	19.89
Petroleum refining	13.43	14.79
Glass	16.58	18.42
Paint and varnish	12.46	15.05
Iron and steel	12.40	13.86
Rayon	14.17	16.28
Textiles	11.07	12.58
Coal products	8.82	9.81
Leather	4.60	4.70
Industrial explosives	5.15	5.74
Rubber	3.00	3.00
Plastics	4.45	4.66
	166.41	179.93



Production and Consumption Trends



CHEMICALS FORMERLY VERY SCARCE ARE NOW OFFERED MORE FREELY FOR INDUSTRIAL USE

While the majority of chemicals continue to find a ready market with no opportunity given to accumulate stock piles, there are exceptions in the case of some important chemicals where production has been stepped up faster than consuming requirements. In some instances this is accounted for by the fact that some military requirements turned out to be less than had been estimated, that requirements were reduced by curtailments in original expansion planning, and because chemical production facilities were not synchronized with those of the prospective consumers. As a case in point, reference may be made to reports that alcohol production would have to be suspended because stocks had increased to a point where they taxed storage facilities. It is true that stocks of alcohol have accumulated with an admission that the current stockpile is in excess of 100,000,000 gal. but the War Production Board has stated that approximately 45,000,000 gal. more can be taken care of by available storage space.

Ammonia which was one of the first chemicals to become scarce as a result of reserving supplies for the manufacture of nitric acid, is now more plentiful and one ranking producer last month announced that anhydrous and aqua ammonia were again available to the pulp and paper industry for use in slime control. Of course this chemical is still subject to allocation but the increase in supply makes it possible to earmark larger amounts for industrial use. Chlorine likewise was one of the original scarce chemicals and it is worthy of note that chlorine for the second three month period of this year was granted in full for all uses for which it was requested subject to the appropriate WPB orders. In individual cases adjustments were made to the allocations because of excessive inventories of chlorine or finished products.

The latest revision of the list of critical chemicals, however, shows that a long line of these products are in small supply. Among those which are classified as most critical are acrylonitrile, aluminum trihydrate, benzol and derivatives, butadiene, cresols, lithium chemicals, monoethanolamine, phenol and derivatives, tricresyl and triphenyl phosphates, styrene, sulfamic acid and toluol and derivatives.

On April 30 WPB announced a rearrangement of the zones under List I. of General Transportation Order T-1. Amendment of the transportation order reduced the number of zones from thirteen to eight. The original order established controls over the use of steel tank cars and tank trucks for delivery of a long list of chemicals. The amendment of April 30 affected only shippers of caustic soda. Beginning May 1 these shippers are permitted to make delivery arrangements on caustic soda in accordance to and within the various zones. In the event the shipper desires to make shipments beyond these zones, he is required to apply to WPB for exemption. Reduction of the number of zones is expected to permit a more flexible use of tank cars and to avoid any delay in the production of chlorine.

Trading in naval stores has been rather quiet. Prices for turpentine have backed and filled but values have steadily returned to the level of a gal. Demand has not been active and despite reports that the new crop movement is slow and that receipts will fall below those of last season, neither turpentine nor rosin makes much price headway although it is held that supplies later on may be small enough to forge advances in sales schedules.

The Salvage Division of the War Production Board has announced an extension of its chemical products reclamation program, designed to make sure that no valuable chemical resources, such as solvents and cleaners, cutting and lubricating oils, paints and chemical byproducts, go down the sewer.

In order that they may help plants to improvise equipment for capturing and salvaging chemical products that would otherwise be wasted and lost to further war use, the Industrial Salvage Branch of the War Production Board has begun a study designed to locate important chemical reclamation opportunities. One thousand large users of chemical products, including manufacturers of munitions, aircraft, heavy machinery, engines, chemicals and plastics, have been asked to report briefly on their chemical products reclamation practices.

Many plants have already developed practical chemical reclamation systems. Their experience will be passed on by the Chemical Resources Section, Industrial Salvage Branch, to other plants which are still wasting chemicals.

This section's study will determine where solvents and cleaners, cutting and lubricating oils used in excess of 5,000 gallons a year and government specification coatings (paint) used in excess of 2,000 gallons a year are now being reclaimed (that is, whether inside or outside the plant) and in what quantity. In cases where reclamation procedures are not adequate, technical services will be supplied to the reporting plants to enable them to institute such procedures on an improvised basis without expenditure of critical materials.

One of the interesting developments in the market for animal fats is the

CHEM. & MET. Weighed Index of CHEMICAL PRICES

Base=100 for 1937

This month	108.88
Last month	108.83
May, 1942	109.40
May, 1941	100.35

Price fluctuations were infrequent in the last month. The tone remains strong as most chemicals are in limited supply and the recent drop in the price for copper sulphate was counter to the general trend. Spirits of turpentine has been steadier.

attempt being made by brokers to retain their position in the industry. Some of the large buyers of fats have acquired the services of brokers as buying agents and there has been a growing trend to eliminate the middle man with sellers reluctant to pay brokerage fees. This led brokers to appeal to the Office of Price Administration for a ruling which would permit buyers of tallow and greases to assume the commissions paid to the brokers.

Stocks of China wood oil were relatively small at the beginning of the year but there has not been much change in the first quarter of this year. Some time ago, prospects for a home production of tung oil were so favorable that predictions of a 10,000,000 lb. crop of oil were heard. Later these estimates were lowered as reports of crop damage were heard. It now is expected that the crop will approximate 6,500,000 lb. While this is quite a drop from the earlier estimates, it will be the largest on record and will compare with 2,300,000 lb. produced last year and 3,533,000 lb. for 1941.

A further curtailment in the use of linseed oil for civilian paints undoubtedly will be necessary to balance future supplies of linseed oil against demand, the Paint, Varnish and Lacquer Industry Advisory Committee was told at a meeting in Washington. It will also be necessary for the industry to practice every possible conservation in using the quota of linseed oil allowed, the committee members were informed.

They were also advised that Preference Rating Order P-65 for marine paints has been amended and reissued by the War Production Board and carries an automatic AA-1 rating on deliveries of raw materials to a producer.

The proposed specific end-use list for protective coatings was discussed in detail. It appeared that this suggested list, if approved by WPB, could be distributed to the trade and used as a "dictionary" of reference, by producers, suppliers, consumers and WPB for the simplification of allocations. The proposal to issue such a list was approved by the committee members and the opinion was expressed that if the list were distributed to all concerned, it would prove most helpful both to the paint, varnish and lacquer industry and to WPB.

CHEM. & MET.

Weighted Index of Prices for

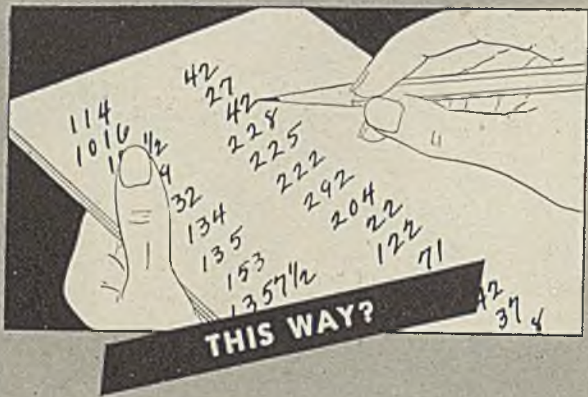
OILS & FATS

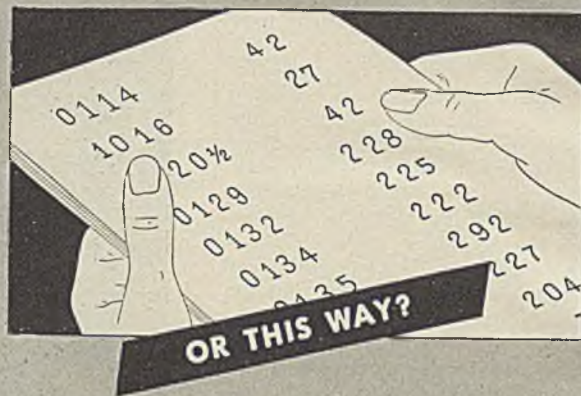
Base=100 for 1937

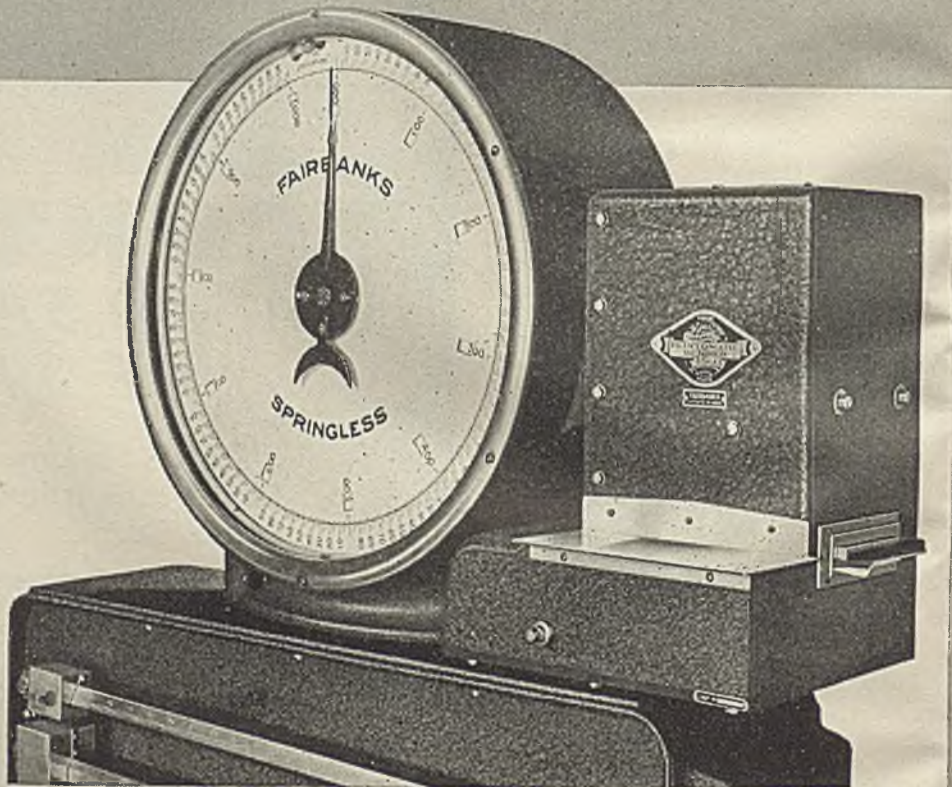
This month	146.03
Last month	146.03
May, 1942	143.93
May, 1941	108.79

Prices for many vegetable oils are little better than nominal in view of the controls over trading. Linseed oil is one of the few not under ceilings and sold off from the peak during the month due to a fall in seed values.

How Are Weight Records Made In Your Plant—







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CURRENT PRICES

INDUSTRIAL CHEMICALS

	Current Price	Last Month	Last Year
Acetone, drums, lb	$0.085–$0.109	$0.085–$0.109	$0.168–$0.173
Acid, acetic, 28%, bbl., cwt	3.38 – 3.63	3.38 – 3.63	3.38 – 3.63
Glacial 99.5%, drums	9.15 – 9.40	9.15 – 9.40	9.15 – 9.40
U. S. P. X 1, 99.5%, dr	10.95 –11.20	10.95 –11.20	10.95 –11.20
Boric, bbl., ton	109.00–113.00	109.00–113.00	109.00–113.00
Citric, kegs, lb	.20 – .23	.20 – .23	.20 – .23
Formic, cbys, lb	.10½– .11	.10½– .11	.10½– .11
Gallic, tech., bbl., lb	1.10 – 1.15	1.10 – 1.15	1.10 – 1.15
Hydrofluoric 30% drums, lb	.08 – .08½	.08 – .08½	.08 – .08½
Lactic, 44%, tech., light, bbl., lb	.073– .075	.073– .075	.073– .075
Muriatic 18°, tanks, cwt	1.05 –......	1.05 –......	1.05 –......
Nitric, 36°, carboys, lb	.05 – .05½	.05 – .05½	.05 – .05½
Oleum, tanks, wks., ton	18.50 –20.00	18.50 –20.00	18.50 –20.00
Oxalic, crystals, bbl., lb	.11½– .13	.11½– .13	.11½– .13
Phosphoric, tech., c'bys., lb	.07½– .08½	.07½– .08½	.07½– .08½
Sulphuric, 60°, tanks, ton	13.00 –......	13.00 –......	13.00 –......
Sulphuric, 66°, tanks, ton	16.50 –......	16.50 –......	16.50 –......
Tannic, tech., bbl., lb	.71 – .73	.71 – .73	.71 – .73
Tartaric, powd., bbl., lb	.70 –......	.70 –......	.70 –......
Tungstic, bbl., lb	nom	nom	nom ......
Alcohol, amyl	......–......	......–......	......–......
From Pentane, tanks, lb	.131–......	.131–......	.131–......
Alcohol, Butyl, tanks, lb	.10¾–......	.10¾–......	.158–......
Alcohol, Ethyl, 190 p'f., bbl., gal	11.94 –......	11.94 –......	8.19 – 8.25
Denatured, 190 proof	......–......	......–......	......–......
No. 1 special, dr., gal. wks	.62 –......	.62 –......	.60 –......
Alum, ammonia, lump, bbl., lb	.03¾– .04	.03¾– .04	.03¾– .04
Potash, lump, bbl., lb	.04¼– .04½	.04¼– .04½	.04 – .04½
Aluminum sulphate, com. bags, cwt	1.15 – 1.40	1.15 – 1.40	1.15 – 1.40
Iron free, bg., cwt	1.85 – 2.10	1.85 – 2.10	1.85 – 2.10
Aqua ammonia, 26°, drums, lb	.02½– .03	.02½– .03	.02½– .03
tanks, lb	.02 – .02¾	.02 – .02¾	.02 – .02¾
Ammonia, anhydrous, cyl., lb	.16 –......	.16 –......	.16 –......
tanks, lb	.04½–......	.04½–......	.04½–......
Ammonium carbonate, powd. tech., casks, lb	.09¼– .12	.09¼– .12	.09¼– .12
Sulphate, wks., ton	29.20 –......	29.20 –......	29.00 –......
Amylacetate tech., from pentane, tanks, lb	.145–......	.145–......	.145–......
Antimony Oxide, bbl., lb	.15 –......	.15 –......	.15 –......
Arsenic, white, powd., bbl., lb	.04 – .04½	.04 – .04½	.04 – .04½
Red, powd., kegs, lb	nom	nom	nom ......
Barium carbonate, bbl., ton	60.00 –65.00	60.00 –65.00	60.00 –65.00
Chloride, bbl., ton	79.00 –81.00	79.00 –81.00	79.00 –81.00
Nitrate, casks, lb	.11 – .12	.11 – .12	.10½– .11
Blanc fix, dry, bbl., lb	.03½– .04	.03½– .04	.03½– .04
Bleaching powder, f.o.b., wks., drums, cwt	2.25 – 2.35	2.25 – 2.35	2.25 – 2.35
Borax, gran., bags, ton	44.00 –......	44.00 –......	44.00 –......
Bromine, cs., lb	.30 – .32	.30 – .32	.30 – .32
Calcium acetate, bags	3.00 –......	3.00 –......	3.00 –......
Arsenate, dr., lb	.07 – .08	.07 – .08	.07 – .08
Carbide drums, lb	.04¾– .05	.04¾– .05	.04¾– .05
Chloride, fused, dr., del., ton	18.00 –24.00	18.00 –24.00	19.00 –24.50
flake, bags., del., ton	18.50 –25.00	18.50 –25.00	20.50 –25.00
Phosphate, bbl., lb	.07½– .08	.07½– .08	.07½– .08
Carbon bisulphide, drums, lb	.05½–......	.05½	.05½–......
Tetrachloride drums, gal	.73 – .80	.73 – .80	.73 – .80
Chlorine, liquid, tanks, wks., 100 lb	2.00 –......	2.00 –......	2.00 –......
Cylinders	.05½– .06	.05½– .06	.05½– .06
Cobalt oxide, cans, lb	1.84 – 1.87	1.84 – 1.87	1.84 – 1.87
Copperas, bgs., f.o.b., wks., ton	18.00 –19.00	18.00 –19.00	18.00 –19.00
Copper carbonate, bbl., lb	.18 – .20	.18 – .20	.18 – .20
Sulphate, bbl., cwt	5.00 – 5.50	5.15 – 5.40	5.15 – 5.40
Cream of tartar, bbl., lb	.57 –......	.57 –......	.57 –......
Diethylene glycol, dr., lb	.14 – .15½	.14 – .15½	.14 – .15½
Epsom salt, dom., tech., bbl., cwt	1.90 – 2.00	1.90 – 2.00	1.90 – 2.00
Ethyl acetate, drums, lb	.12 –......	.12 –......	.12 –......
Formaldehyde, 40%, bbl., lb	.05½– .06	.05½– .06½	.05½– .06
Furfural, tanks, lb	.09 –......	.09 –......	.09 –......
Fusel oil, drums, lb	.18 – .19	.18 – .19	.18 – .19
Glaubers salt, bags, cwt	1.05 – 1.10	1.05 – 1.10	1.05 – 1.10
Glycerine, c.p., drums, extra, lb	.18¼–......	.18¼–......	.18¼–......

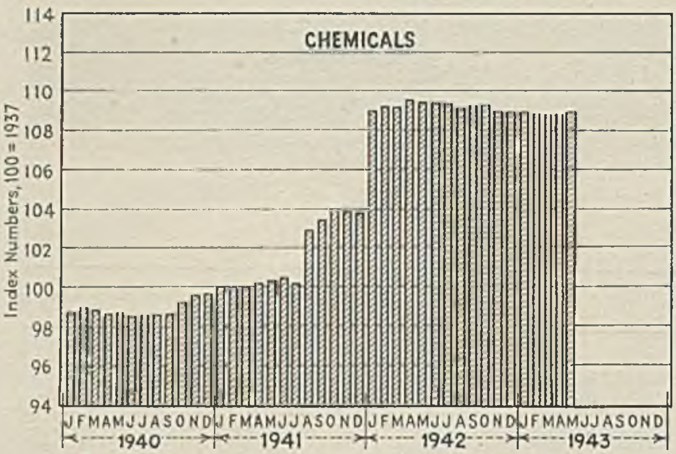
	Current Price	Last Month	Last Year
Lead:			
White, basic carbonate, dry casks, lb	.08½–......	.08½–......	.08½–......
White, basic sulphate, sck., lb	.07½–......	.07½–......	.07½–......
Red, dry, sck., lb	.09½–	.09½–......	.09½–......
Lead acetate, white crys., bbl., lb	.12½– .13	.12½– .13	.12½– .13
Lead arsenate, powd., bag, lb	.11 – .12	.11 – .12	.11 – .12
Lime, chem., bulk, ton	8.50 –......	8.50 –......	8.50 –......
Litharge, powd., csk., lb	.08½–......	.08½–......	.08½–......
Lithopone, bags, lb	.04¼– .04½	.04¼– .04½	.04¼– .04½
Magnesium carb., tech., bags, lb	.06½– .06½	.06½– .06½	.06½– .06½
Methanol, 95%, tanks, gal	.58 –......	.58 –......	.60 –......
97%, tanks, gal	.58 –......	.58 –......	.60 –......
Synthetic, tanks, gal	.28 –......	.28 –......	.28 –......
Nickel salt, double, bbl., lb	.13½– .13½	.13½– .13½	.13½– .13½
Orange mineral, csk., lb	.12½–......	.12½–......	.12½–......
Phosphorus, red, cases, lb	.40 – .42	.40 – .42	.40 – .42
Yellow, cases, lb	.18 – .25	.18 – .25	.18 – .25
Potassium bichromate, casks, lb	.09¼– .10	.09¼– .10	.09¼– .10
Carbonate, 80–85%, calc. csk., lb	.06½– .07	.06½– .07	.06½– .07
Chlorate, powd., lb	.10 – .12	.10 – .12	.10 – .12
Hydroxide (c'stic potash) dr., lb	.07 – .07½	.07 – .07½	.07 – .07½
Muriate, 60% bags, unit	.53½–......	.53½–......	.53½–......
Nitrate, bbl., lb	.05½– .06	.05½– .06	.05½– .06
Permanganate, drums, lb	.19½– .20	.19½– .20	.19½– .20
Prussiate, yellow, casks, lb	.17 – .18	.17 – .18	.17 – .18
Sal ammoniac, white, casks, lb	.0515– .06	.0515– .06	.0515– .06
Salsoda, bbl., cwt	1.00 – 1.05	1.00 – 1.05	1.00 – 1.05
Salt cake, bulk, ton	17.00 –......	17.00 –......	17.00 –......
Soda ash, light, 58%, bags, contract, cwt	1.05 –......	1.05 –......	1.05 –......
Dense, bags, cwt	1.10 –......	1.10 –......	1.10 –......
Soda, caustic, 76%, solid, drums, cwt	2.30 – 3.00	2.30 – 3.00	2.30 – 3.00
Acetate, del., bbl., lb	.05 – .06	.05 – .06	.05 – .06
Bicarbonate, bbl., cwt	1.70 – 2.00	1.70 – 2.00	1.70 – 2.00
Bichromate, casks, lb	.07¼– .08	.07¼– .08	.07¼– .08
Bisulphate, bulk, ton	16.00 –17.00	16.00 –17.00	16.00 –17.00
Bisulphite, bbl., lb	.03 – .04	.03 – .04	.03 – .04
Chlorate, kegs, lb	.06½– .06½	.06½– .06½	.06½– .06½
Cyanide, cases, dom., lb	.14 – .15	.14 – .15	.14 – .15
Fluoride, bbl., lb	.08 – .09	.08 – .09	.08 – .09
Hyposulphite, bbl., cwt	2.40 – 2.50	2.40 – 2.50	2.40 – 2.50
Metasilicate, bbl., cwt	2.50 – 2.65	2.50 – 2.65	2.50 – 2.65
Nitrate, bulk, cwt	1.35 –......	1.35 –......	1.35 –......
Nitrite, casks, lb	.06¼– .07	.06¼– .07	.06¼– .07
Phosphate, tribasic, bags, lb	2.70 –......	2.70 –......	2.70 –......
Prussiate, yel. drums, lb	.10½– .11	.10½– .11	.10½– .11
Silicate (40° dr.), wks., cwt	.80 – .85	.80 – .85	.80 – .85
Sulphide, fused, 60–62%, dr. lb	.03 – .03½	.03 – .03½	.03 – .03½
Sulphite, crys., bbl., lb	.02½– .02¾	.02½– .02¾	.02½– .02¾
Sulphur, crude at mine, long ton	16.00 –......	16.00 –......	16.00 –......
Chloride, dr., lb	.03 – .04	.03 – .04	.03 – .04
Dioxide, cyl., lb	.07 – .08	.07 – .08	.07 – .08
Flour, bag, cwt	1.90 – 2.40	1.90 – 2.40	1.90 – 2.40
Tin Oxide, bbl., lb	.55 –......	.55 –......	.55 –......
Crystals, bbl., lb	.39½–......	.39½–......	.39½–......
Zinc, chloride, gran., bbl., lb	.05¾– .06	.05¾– .06	.05 – .06
Carbonate, bbl., lb	.14 – .15	.14 – .15	.14 – .15
Cyanide, dr., lb	.33 – .35	.33 – .35	.33 – .35
Dust, bbl., lb	.1035–......	.1035–......	.09½–......
Oxide, lead free, bag, lb	.07¼–......	.07¼–......	.07¼–......
5% leaded, bags, lb	.07¼–......	.07¼–......	.07¼–......
Sulphate, bbl., cwt	3.85 – 4.00	3.85 – 4.00	3.40 – 3.50

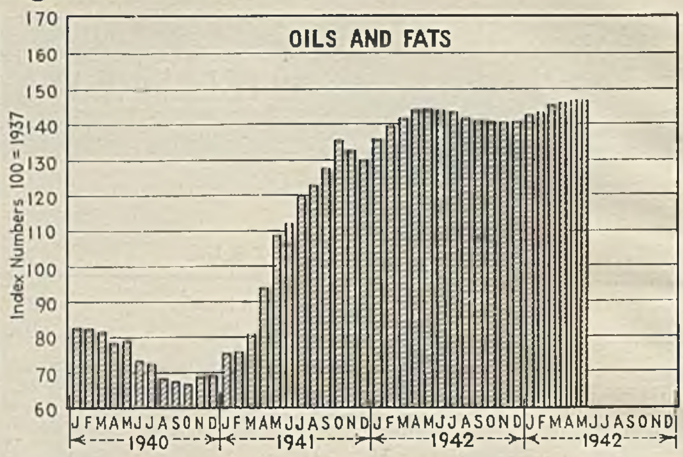
OILS AND FATS

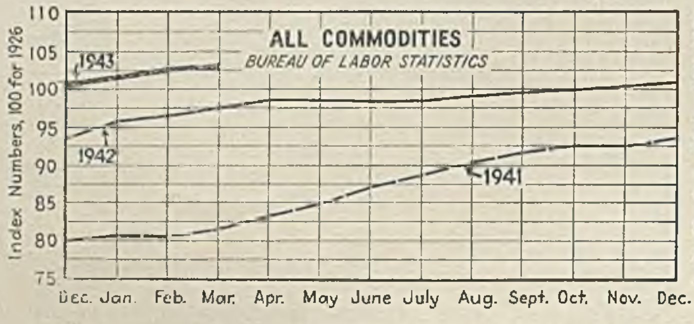
	Current Price	Last Month	Last Year
Castor oil, No. 3 bbl., lb	$0.13¾–$0.14½	$0.13¾–$0.14½	$0.13¾–$0.14½
Chinawood oil, bbl., lb	.38 –......	.38 –......	.38 –......
Coconut oil, Ceylon, tank, N. Y., lb	nom	nom	nom ......
Corn oil crude, tanks (f.o.b. mill), lb	.12¾–......	.12¾–......	.12¾–......
Cottonseed oil, crude (f.o.b. mill), tanks, lb	.12¾–......	.12¾–......	.12¾–......
Linseed oil, raw car lots, bbl., lb	.156–......	.158–......	.141–......
Palm, casks, lb	.09 –......	.09 –......	.09 –......
Peanut oil, crude, tanks (mill), lb	.13 –......	.13 –......	.13 –......
Rapeseed oil, refined, bbl., lb	nom	nom	nom ......
Soya bean, tank, lb	.11¾–......	.11¾–......	.11¾–......
Sulphur (olive foots), bbl., lb	nom	nom	.19½–......
Cod, Newfoundland, bbl., gal	nom	nom	nom ......
Menhaden, light pressed, bbl., lb	.117–......	.117–......	.114–......
Crude, tanks (f.o.b. factory) lb	.088–......	.088–......	.088–......
Grease, yellow, loose, lb	.08¼–......	.08¼–......	.09295......
Oleo stearine, lb	.09½–......	.09½–......	.09½–......
Oleo oil, No. 1	.11½–......	.11½–......	.11½–......
Red oil, distilled, dp.p. bbl., lb	.11¾–......	.11–¾......	.12 –......
Tallow extra, loose, lb	.08¾–......	.08¾–......	.097125....

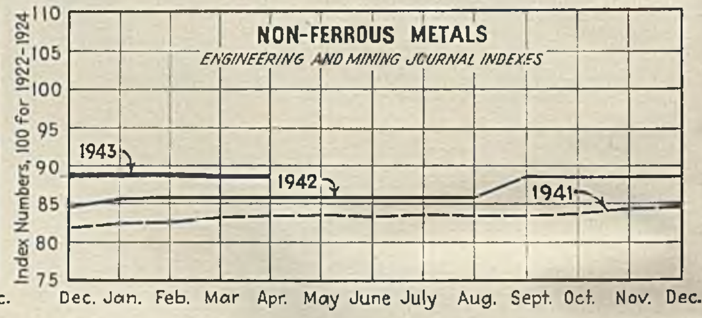
The accompanying prices refer to round lots in the New York market. Where it is the trade custom to sell f.o.b. works, quotations are given on that basis and are so designated. Prices are corrected to May 13

Chem. & Met.'s Weighted Price Indexes









Coal-Tar Products

	Current Price	Last Month	Last Year
Alpha-napthol, crude bbl., lb.	$0.52– $0.55	$0.52– $0.55	$0.52 –$0.55
Alpha-naphthylamine, bbl., lb.	.32 – .34	.32 – .34	.32 – .34
Aniline oil, drums, extra, lb.	.15 – .16	.15 – .16	.15 – .16
Aniline, salts, bbl., lb.	.22 – .24	.22 – .24	.22 – .24
Benzaldehyde, U.S.P., dr., lb.	.85 – .95	.85 – .95	.85 – .95
Benzidine base, bbl., lb.	.70 – .75	.70 – .75	.70 – .75
Benzoic acid, U.S.P., kgs., lb.	.54 – .56	.54 – .56	.54 – .56
Benzyl chloride, tech., dr., lb.	.23 – .25	.23 – .25	.23 – .25
Benzol, 90%, tanks, works, gal.	.15 –......	.15 –......	.14 –......
Beta-naphthol, tech., drums, lb.	.23 – .24	.23 – .24	.23 – .24
Cresol, U.S.P., dr., lb.	.11 –......	.11 – .11	.10½– .11
Cresylic acid, dr., wks., gal.	.81 – .83	.81 – .83	.81 – .83
Diethylaniline, dr., lb.	.40 – .45	.40 – .45	.40 – .45
Dinitrophenol, bbl., lb.	.23 – .25	.23 – .25	.23 – .25
Dinitrotoluol, bbl., lb.	.18 – .19	.18 – .19	.18 – .19
Dip oil, 15%, dr., gal.	.23 – .25	.23 – .25	.23 – .25
Diphenylamine, dr. f.o.b. wks., lb.	.60 –......	.60 –......	.70 –......
H-acid, bbl., lb.	.45 – .50	.45 – .50	.45 – .50
Naphthalene, flake, bbl., lb.	.07 – .07½	.07 – .07½	.07 – .07½
Nitrobenzene, dr., lb.	.08 – .09	.08 – .09	.08 – .09
Para-nitraniline, bbl., lb.	.47 – .49	.47 – .49	.47 – .49
Phenol, U.S.P., drums, lb.	.10½– .11	.10½– .11	.13 –......
Picric acid, bbl., lb.	.35 – .40	.35 – .40	.35 – .40
Pyridine, dr., gal.	1.70 – 1.80	1.70 – 1.80	1.70 – 1.80
Resorcinol, tech., kegs., lb.	.75 – .80	.75 – .80	.75 – .80
Salicylic acid, tech., bbl., lb.	.33 – .40	.33 – .40	.33 – .40
Solvent naphtha, w.w., tanks, gal.	.27 –......	.27 –......	.27 –......
Tolidine, bbl., lb.	.86 – .88	.86 – .88	.86 – .88
Toluol, drums, works, gal.	.33 –......	.33 –......	.32 –......
Xylol, com., tanks, gal.	.26 –......	.26 –......	.26 –......

Miscellaneous

	Current Price	Last Month	Last Year
Barytes, grd., white, bbl., ton.	$22.00–$25.00	$22.00–$25.00	$22.00–$25.00
Casein, tech., bbl., lb.	.21 – .23½	.21 – .23½	.20 – .25
China clay, dom., f.o.b. mine, ton.	8.00 –20.00	8.00 –20.00	8.00 –20.00
Dry colors			
Carbon gas, black (wks.), lb.	.0335– .30	.0335– .30	.0335– .30
Prussian blue, bbl., lb.	.36 – .37	.36 – .37	.36 – .37
Ultramarine blue, bbl., lb.	.11 – .26	.11 – .26	.11 – .26
Chrome green, bbl., lb.	.21½– .30	.21½– .30	.21½– .30
Carmine, red, tins, lb.	4.60 – 4.75	4.60 – 4.75	4.60 – 4.75
Para toner, lb.	.75 – .80	.75 – .80	.75 – .80
Vermilion, English, bbl., lb.	3.05 – 3.10	3.05 – 3.10	3.05 – 3.10
Chrome yellow, C.P., bbl., lb.	.14½– .15½	.14½– .15½	.14½– .15½
Feldspar, No. 1 (f.o.b.N.C.), ton.	6.50 – 7.50	6.50 – 7.50	6.50 – 7.50
Graphite, Ceylon, lump, bbl., lb.	.08 – .10	.08 – .10	.08 – .10
Gum copal Congo, bags, lb.	.09 – .30	.09 – .30	.09 – .30
Manila, bags, lb.	.09 – .15	.09 – .14	.09 – .15
Demar, Batavia, cases, lb.	.10 – .22	.10 – .20	.10 – .22
Kauri, cases, lb.	.18 – .60	.17 – .60	.18 – .60
Kieselguhr (f.o.b. mines), ton.	7.00 –40.00	7.00 –40.00	7.00 –40.00
Magnesite, calc, ton.	64.00 –......	64.00 –......	64.00 –......
Pumice stone, lump, bbl., lb.	.05 – .07	.05 – .08	.05 – .07
Imported, casks, lb.	nom	nom	nom ......
Rosin, H., 100 lb.	4.10 –......	4.05 –......	3.39 –......
Turpentine, gal.	.70½–......	.69½–......	.67 –......
Shellac, orange, fine, bags, lb.	.39 –......	.39 –......	.43 –......
Bleached, bonedry, bags, lb.	.39 –......	.39 –......	.40 –......
T. N. bags, lb.	.31 –......	.31 –......	.32 –......
Soapstone (f.o.b. Vt.), bags, ton.	10.00 –12.00	10.00 –12.00	10.00 –12.00
Talc. 200 mesh (f.o.b. Vt.), ton.	8.00 – 8.50	8.00 – 8.50	8.00 – 8.50
200 mesh (f.o.b. Ga.), ton.	6.00 – 8.00	6.00 – 8.00	6.00 – 8.00

Industrial Notes

Robins Conveying Belt Co., Passaic, N. J., has changed its name to Robins Conveyors, Inc.

Fairbanks, Morse & Co., Chicago, has appointed Robert H. Morse, Jr., general sales manager.

Henry L. Crowley & Co., West Orange, N. J., has appointed Earl S. Patch sales manager.

E. M. Sergeant Pulp and Chemical Co., Inc., New York, has established a manufacturing subsidiary, the Sergeant Chemical Co. located at 120 Lister Ave., Newark, N. J.

American Brake Shoe and Foundry Co., New York, has shortened its name and will do business as the American Brake Shoe Co.

Nitrogen Products, Inc., New York, has moved its executive offices to 630 Fifth Ave.

Claude B. Schneible Co., Chicago, has promoted C. C. Hermann to the position of general manager and has named L. C. Beers sales manager.

The Cement Tile Corp., Chicago, has been formed with offices at 608 South Dearborn St. Officers are C. S. Freund, president; L. J. Wilhartz, vice-president; A. Isherwood, secretary and sales manager; V. E. Baird, treasurer and chief engineer; and O. R. Pritchett, assistant secretary and plant manager.

Copperweld Steel Co., Warren, Ohio, has opened sales offices in the Circle Tower, Indianapolis and appointed M. A. Williams district sales manager.

Globe Steel Tubes Co., Milwaukee, has made C. J. Bickler assistant to the vice-president in charge of sales.

Koppers Co., Pittsburgh, has transferred its New England district offices from Providence to the Consolidated Gas Bldg., Boston. Maurice D. Gill vice-president of the company is manager of the district.

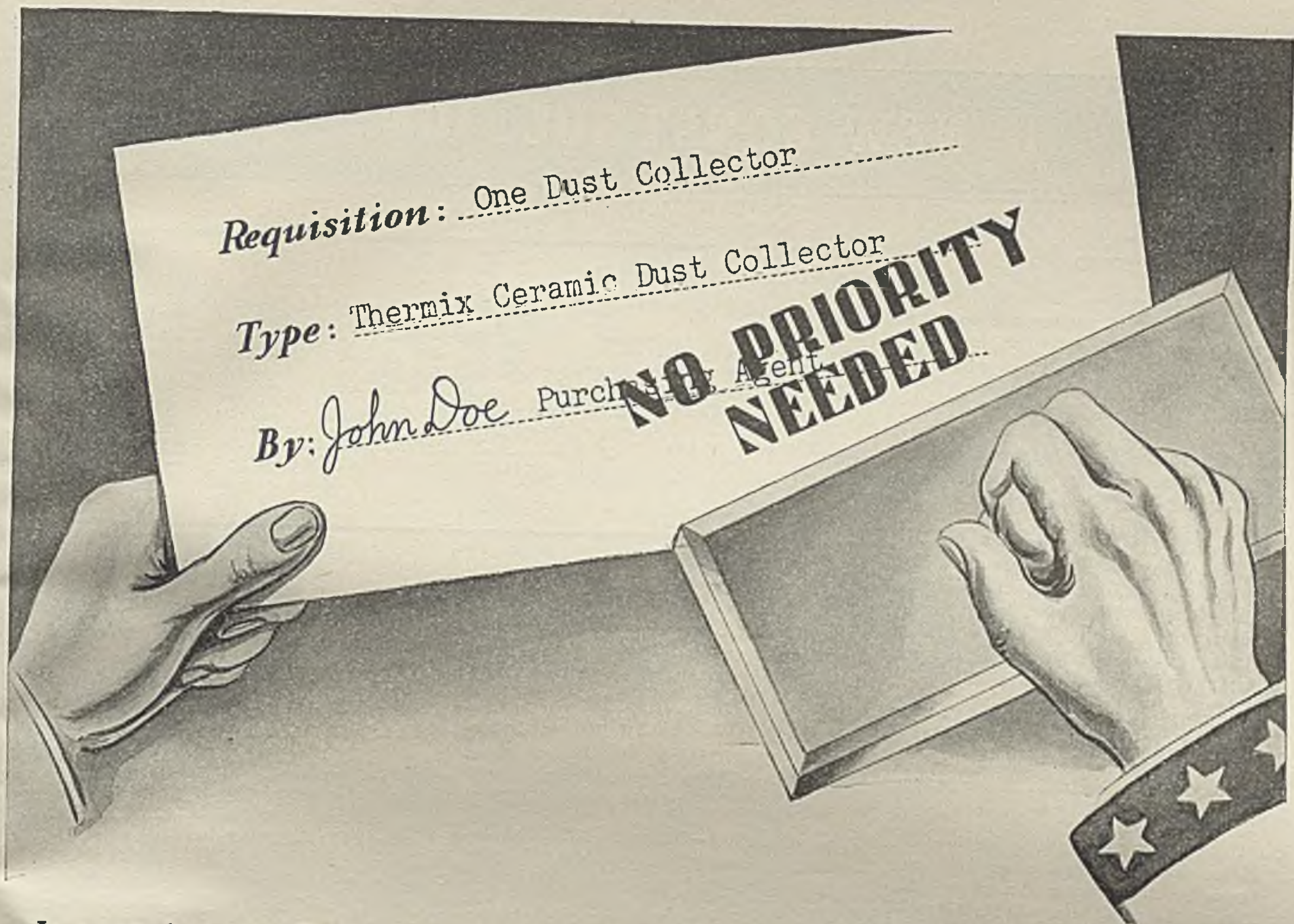
Shell Oil Co., New York, has transferred John Southworth from San Francisco to Detroit where he will serve as manager.

Triumph Explosives, Inc., Elkton, Md., has named Samuel L. H. Burk, director of industrial relations.

Chain Belt Co., Milwaukee, has moved William W. Klemme from Buffalo to Dallas, Texas, where he will act as district sales manager.

The Baker-Raulang Co., Cleveland, announces that J. K. Mahaffey is now associated with George H. Criss representing the company in the Pittsburgh territory.

S. K. F. Industries, Inc., Philadelphia, has elected Thomas W. Dinlocker, vice-president and treasurer, Richard H. DeMott, vice-president in charge of sales, and C. P. Collins, secretary. William L. Batt retains the presidency.



As a part of our war effort to conserve steel and enable you to get a dust collector *without a priority,* the Thermix is now constructed with tubes made of tough fire clay instead of steel.

These ceramic tubes are so rugged that they will withstand temperature changes and normal handling without breakage. But should they be accidently damaged they can be easily and quickly replaced at small cost from our large stock.

Another feature of these improved tubes is that they eliminate corrosion, reduce erosion and permit installation of the dust collector outside the plant, if desired, without any additional protecting structure.

Like the hundreds of steel Thermix Tubular Dust Collectors installed throughout the country during the past years, the Thermix CERAMIC Dust Collector assures high efficiency collection of fine dusts, powders and fly-ash.

Write for Bulletin and full particulars

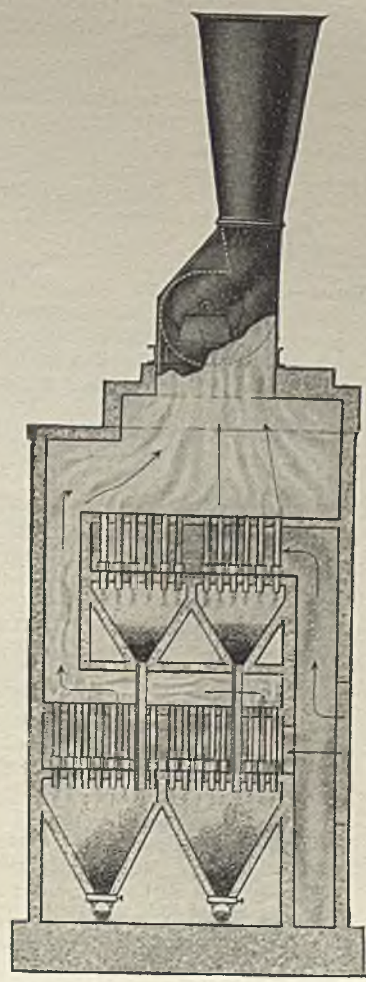
PRAT-DANIEL CORPORATION, Port Chester, N. Y.

General Sales Agents

Thermix Engineering Co., Greenwich, Conn.

Representatives in Principal Cities

Thermix Ceramic DUST COLLECTOR



NEW CONSTRUCTION

	Current Projects		Cumulative 1943	
	Proposed Work	Contracts	Proposed Work	Contracts
New England	$40,000	....	$120,000	$265,000
Middle Atlantic	40,000	$80,000	13,930,000	1,900,000
South	245,000	2,000,000	2,213,000	5,600,000
Middle West	....	40,000	8,530,000	8,495,000
West of Mississippi	1,320,000	....	10,610,000	9,230,000
Far West	....	595,000	1,850,000	6,376,000
Canada	699,000	310,000	4,244,000	1,127,000
Total	$2,344,000	$3,025,000	$41,497,000	$32,993,000

PROPOSED WORK

Conn., Stamford — Northam Warren Corp., Barry Pl., plans the construction of an addition to its plant here. Estimated cost will exceed $40,000.

Mo., St. Joseph—Blanton Co., 3400 North Wharff St., plans to construct a soybean crushing plant on Buchanan St. between Commercial St. and tracks of Chicago, Burlington & Quincy R. R. tracks.

Mo., St. Joseph—Sharp & Dohme, Inc., Broad and Wallace Sts., Philadelphia, Pa., plans improvements to its serum plant including virum unit building, stock pens and installation of new equipment. Estimated cost $75,000.

N. J., Belleville—Bart Laboratories, 227 Main St., plans to construct a 2 story manufacturing building addition. V. M. Reynal, 380 Main St., East Orange, Archt.

N. C., Hazelwood—Dayton Rubber Co., Hazelwood, will soon award the contract for the construction of an addition to its tire factory here. Geyer & Neuffer, 437 Ludlow Arcade, Dayton, O., Archts & Engrs. Estimated cost $175,000.

South Carolina—Pittsburgh Metallurgical Co., Inc., 3801 Highland Ave., Niagara Falls, N. Y., plans to construct additional plant facilities here. Project will be financed by Defense Plant Corp., Washington, D. C. Estimated cost $70,000.

Texas—Defense Plant Corp., 811 Vermont Ave., N. W., Washington, D. C., plans to improve and enlarge refinery which is operated by Taylor Refining Co., Taylor. Estimated cost $1,000,000.

Texas, Beaumont—Pure Oil Co., Beaumont, plans to rebuild its refinery in the Beaumont-Smith's Bluff area in Jefferson Co. Estimated cost will exceed $40,000.

Tex., Edinburg—McBride Refining Co., Edinburg, plans the construction of a gasoline refinery here. Estimated cost $125,000.

Tex., LaBlanca—Dr. Burton McCollum, Esperson Bldg., Houston, plans the construction of an experimental plant in this area to obtain chemicals from recycling plant dry gas.

Man., Alberta—Dominion Government, Ottawa, Ont., plans to improve its existing plant and also construct new plant for extracting oil from the Alberta Tar Sands. Estimated cost $500,000.

Ont., Niagara Falls—North American Cyanamid, Ltd., 7 Fourth St., plans to construct an addition to its plant including a medical service building. Estimated cost $50,000.

Ont., St. Catherines—McKinnon Industries, Ltd., Ontario St., Ottawa, plans to alter its plant here and install new equipment. Estimated cost $96,550.

Que., Chandler—Gaspesia Sulphite Co., Ltd., Chandler, plans alterations and improvements to its plant. Estimated cost $52,000.

CONTRACTS AWARDED

Calif., Berkeley—Linde Air Products Co., 1150 Eighth St., has awarded the contract for the construction of a factory to Swinerton & Walberg, 225 Bush St., San Francisco.

Calif., Santa Maria—Union Oil Co., 617 West 7th St., Los Angeles, has awarded the contract for the construction of a gasoline absorption plant in the Santa Maria Valley to Fluor Corp., P. O. Box 7030, Los Angeles. Estimated cost $500,000.

N. Y., Buffalo—Donner-Hanna Coke Corp., Abby and Mystic Sts., has awarded the contract for 15 Koppers-Becker type by-products under jet coke ovens to Koppers Co., Koppers Bldg., Pittsburgh, Pa.

Pa., McKeesport—Carnegie Illinois Steel Co., M. W. Reed, Ch. Engr., Carnegie Bldg., Pittsburgh, has awarded the contract for the construction of a 2 story, 23½x55½ ft. metallurgical laboratory building addition to G. H. Chilli, First Natl. Bank Bldg., Homestead.

Utah, Salt Lake City—Utah Oil Refining Co., Utah Oil Bldg., has awarded the contract for structures for a high Octane gasoline plant to M. B. Garff, 2256 Oneida St. Estimated cost $55,000.

W. Va., Martinsburg—Explosive Products Corp., Washington Bldg., Wash., D. C., will construct a plant consisting of 18 buildings, including power plant, hospital, etc. Workmen's Housing Corp., W. F. Bennett, Jr., United Bank Bldg., Cleveland, O., Archt. and Engr. Work will be done by day labor. Estimated cost $2,000,000.

Wisconsin—Kelvinator Corp., 5625 25th Ave., Kenosha, has awarded the contract for altering its chemical and physical laboratory building to Lindemann Construction Co., 4724 5th Ave., Kenosha. Project will be financed by Defense Plant Corp., Washington, D. C.

N. S., Halifax—Richmond Paper Co., Ltd., Kempt Rd., has awarded the contract for the construction of a 1 story, 75x210 ft. brick warehouse on Robie St., to W. G. Foley, St. Albans St. Estimated cost $45,000.

Ont., Toronto—Plibrico Jointless Firebrick, Ltd., 863 Lakeshore Rd., has awarded the contract for the construction of a 1 story, 50x136 ft. addition to its plant on Horner Ave., to Richardson Construction Co., Ltd., 10 Adelaide St., E., Toronto. Estimated cost $40,000.

Ont., Welland — Electro - Metallurgical Co. of Canada, Ltd., Welland, has awarded the contract for the construction of a 2 story, 50x175 ft. addition to its plant to Gardner Construction Co., Ltd., 7 Riverbank St., Welland. Estimated cost $145,000.

Que., Montreal—Dominion Oilcloth & Linoleum Co., Ltd., 2200 East St. Catherine St., has awarded the contract for the construction of an addition to its plant to Cook & Leitch, 1440 West St. Catherine St. Estimated cost $40,000.

Que., Montreal—Shell Oil Co., Ltd., 660 West St. Catherine St., has awarded the contract for the construction of an addition to its plant to James Thom & Co., Ltd., 660 West St. Catherine St. Estimated cost $40,000.

...back from danger

Safe on the carrier's deck, the Wildcat returns from a mission of danger! The giant Wasp engine in its nose has roared it to Victory—and brought it back, safe.

The engineering problems represented by these 18 powerful cylinders are staggering. Take the matter of reduction gears alone. Stepping down the high speed of the whirling crankshaft to the necessary slower propeller revolutions requires gears of such light weight and such extreme precision that only a slight variation would quickly spell their destruction. And yet, the flow of engines coming off production lines to power the world's mightiest air armada demands that these gears be produced by the hundreds of thousands.

And making these gears is Foote Bros.' job—a job that only a few months ago was considered well nigh impossible. How new production techniques—new engineering developments—resulted in the present production that keeps three plants of Foote Bros. Gear and Machine Corporation busy cannot be revealed until the war is won. But when "V" Day comes, these manufacturing know-hows can be applied to the making of precision gears for any product where close tolerances can aid in securing better performance and greater economy.

FOOTE BROS. GEAR AND MACHINE CORPORATION • 5225 S. Western Boulevard, Chicago, Illinois

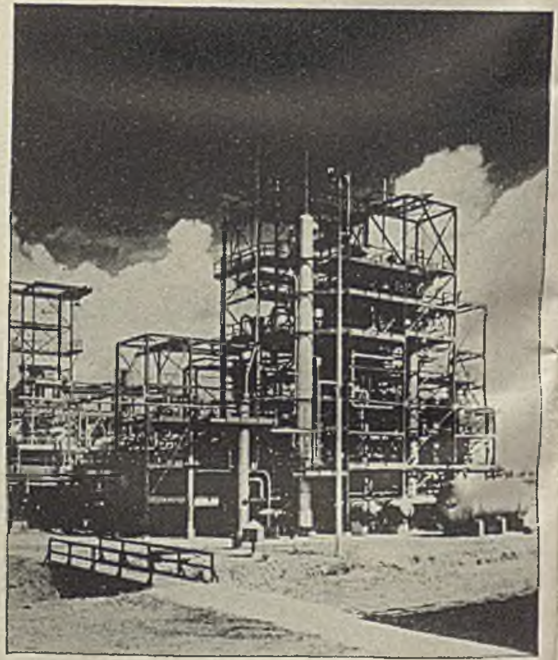
The Grumman Wildcat pictured here has been the Navy's first line fighter since Pearl Harbor. O'Hare, Thatch, Gaylord and other Navy Aces became famous in the cockpit of this tough plane.

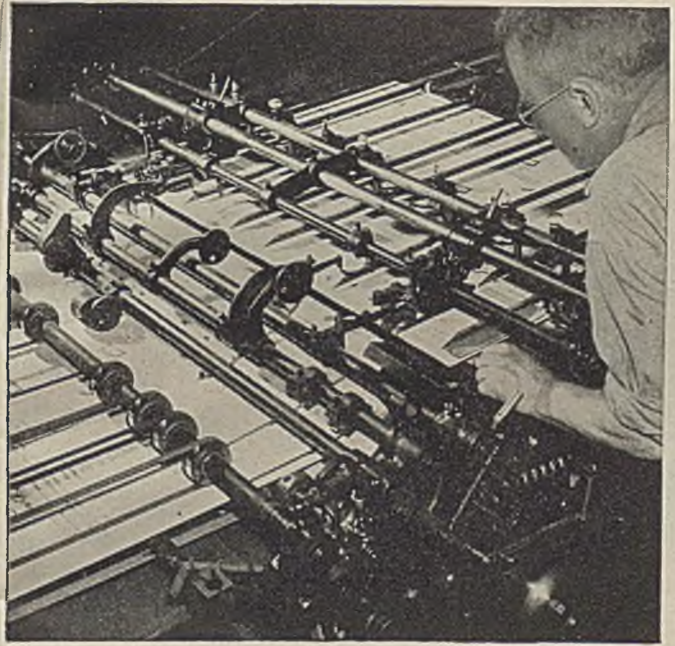
Life ON THE CHEMICAL NEWSFRONT

(*Above*) **YOU CAN PROTECT SIX SOLDIERS** from head injuries under fire by investing in one $25 War Bond for only $18.75, the cost of six of the new type steel helmets worn by Uncle Sam's fighting men. And the regular purchase of War Bonds or Stamps every pay day will help to finance the production of other vital equipment to safeguard America's freedom.

(*Below*) **AVIATOR COATS AND ARMY SHOES** are two of the most important outlets for leather today. TWECOTAN*, Cyanamid's new line of vegetable tanning extracts, contributes greatly towards improving quality and uniformity of these types of leather. Also used in their production are other Cyanamid tanning specialties, such as DEPILIN* Unhairing Agent, CUTRILIN* Bate, TANAK* Synthetic Tanning Material, and BETASOL* Wetting Agents.

(*Below*) **POWER FOR AIR LEADERSHIP** is being aided by Cyanamid's manufacture of Synthetic "Fluid" Cracking Catalyst needed for the production of vital 100 octane-plus aviation gasoline. The manufacture of catalysts is not a new field for Cyanamid. For more than 15 years this company has turned out chemical catalysts for the production of sulfuric acid, ammonia, and carbon monoxide. Synthetic Cracking Catalysts have been made by Cyanamid since 1939. Catalytic cracking units representing the last word in petroleum technology have recently been erected throughout the country to meet today's accelerated demands.

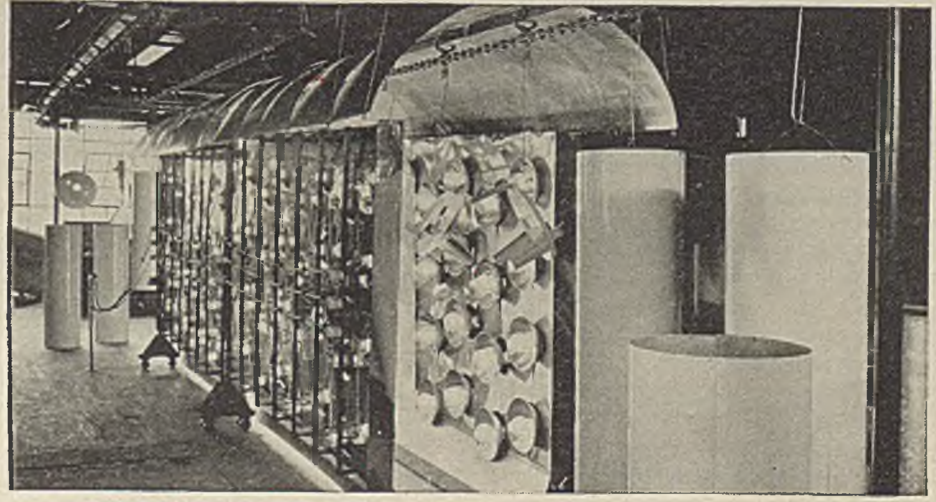




(*Above*) **SMOOTH SURFACE UNDER PRESSURE,** "cushion," resistance to ink penetration, and elimination of fuzz are qualities that can be obtained in fine printing paper by using small quantities of wax emulsion with rosin size during manufacture. Producing a broad range of paper-making staples and specialties, Cyanamid extends experienced counsel on chemical problems in paper making.

(*Above*) **AN ESSENTIAL TO FOOD PRODUCTION,** phosphate deposits like those being mined by Cyanamid in Florida are helping to assure self-sufficiency for the United Nations. Much of the phosphate rock is sold to fertilizer manufacturers for processing into plant food known as superphosphate and for use in the chemical, drug, mining, petroleum, and munition industries. American Cyanamid, one of the country's largest suppliers of phosphate rock, has greatly increased the efficiency of its mining and processing, thus contributing to the conservation of the basic supply.

(*Right*) **WET TO DRY** is only a matter of minutes for baking finishes, thanks to the speedy action obtained with batteries of infrared lamps such as this. Painted products of varying sizes can be passed through them on conveyor belts in a continuous stream to effect important savings in time over former drying methods. To help overcome the present shortage of certain critical paint ingredients, Cyanamid research chemists have developed vehicles made from oils that are considered least critical today. They provide the good hardness, gloss and color retention necessary to meet Army Ordnance, Maritime, and similar U. S. Government specifications. Formulators are further aided by the extensive line of resins and other materials that Cyanamid has developed for many new and improved types of surface coatings.



*Trade-Mark

American Cyanamid & Chemical Corporation

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