CHEMICAL
& METALLURGICAL
ENGINEERING

ESTABLISHED 1902

S. D. KIRKPATRICK, Editor

AUGUST, 1942

CONGRESSIONAL ENGINEERING

More chemical engineering, or what passes as such, is going into the *Congressional Record* than ever before in the history of that amazing publication. The newspapers are running a close second. Everybody except chemical engineers themselves seems to know just how the butadiene, alcohol, synthetic rubber and related problems are to be solved. There are partisans for every process as well as opponents for every proposal. The man in the street has become badly confused. He wants a new set of tires and he doesn't care much whether the rubber is farm-grown, processed from petroleum or coaxed out of coal. His homely advice is—"Quit talking and get going! Push all your processes as fast as you can and for all they are worth!" And, strangely enough, that is about the soundest advice we can get from any disinterested chemical engineers who are qualified to pass judgment. They say that only with the maximum effort and maximum success along many lines can we hope to meet even our most critical needs.

All agree that the rubber program has been badly mishandled, almost from the start. In the earlier stages there were mistakes of judgment in relying too heavily on the selling arguments of the Dutch and English syndicates, supported by certain promises of our own Navy. Then when the situation became serious, responsibility was divided between different governmental agencies whose negotiations were cloaked with unnecessary and suspicious secrecy. Congress stepped in and added to the confusion. The farm bloc saw an opportunity to push certain uneconomic and unorthodox proposals and did so to the extent of passing a bill to set up an independent agency to control that portion of the synthetic rubber program produced from farm and forest products. Thus the demands of the stronger pressure group in our farm-labor government were brazenly placed ahead of the public interest.

What was to be done? Apparently when President Roosevelt first asked himself that question, he hit upon the idea of putting the whole thing up to some man or group of men in whom the public would have fullest confidence. The findings of such a "Supreme Court" he felt might be accepted as the basis for a sound national policy. His selection of such men as Bernard Baruch, President Conant of Harvard and President Compton of M.I.T. meets with wide approval. With a business man and elder statesman in war industries as chairman and with both chemical and engineering talents ably represented, there should be a true appreciation of the three important phases of the rubber problem.

But it would be a great mistake, in our opinion, if the public is led to believe that the President's commission can or will pick any single process or raw material source as the sole basis on which we are to build our synthetic rubber industry. There are too many conflicting factors and variables to evaluate. The problem is so complicated and the responsibility so heavy that no possible group of "experts" can bring in a cut-and-dried solution.

Elsewhere in this issue is the announcement of the organization of a Referee Board of the Chemical Division of W.P.B. which is made up of twelve chemists and chemical engineers. Six of these men come from the faculties of American universities and six come from industry. None represents a single client, industry or viewpoint. There is wide geographical spread among their membership. None can claim expertness or experience in synthetic rubber industry. But despite such apparent qualifications, we feel certain that these men would not welcome, individually or as a group, any commission that would set them up as a tribunal to pass on a single solution for technical, economic and political problems involved in the present rubber situation. It is better that we work our way out, pushing all of our processes as hard and as fast as we can. The sum of all our efforts will not be too much nor too soon.

FROM AN

SETTING SOME RECORDS

ACCORDING to the voluntary code of wartime practices established by the Office of Censorship, the American press is asked not to publish certain specific information "except when such information is made available officially by appropriate authorities." So we are particularly pleased to have as our "appropriate authority" Mr. Donald M. Nelson, whose official statement of July 26 had the following to say in reference to one of the jobs that chemical engineers are helping to do for their country:

> Explosives and ammunition are being made at many times the rate of last year as newly constructed plants come into operation. TNT is being made at a rate five times that before Pearl Harbor. Smokeless powder is being produced at a rate almost twice that before Pearl Harbor. One new plant is making more TNT than the entire explosives industry produced in peacetime and there are several of this type of plant.

Major General William N. Porter, Chief of the Chemical Warfare Service of the U. S. Army, told the American Legion at Asheville, N. C., on June 21 some things about the sort of bombs that General Doolittle's boys showered on Tokio. He said:

> By a miracle of production these bombs were rolling within a few weeks after we were in the war,—rolling not by the hundreds or even thousands, but by the millions—and this, I may add, with substitute materials where critical materials were being used for other purposes until production could catch up. I am proud of this achievement—proud of the thousands of men and women in the United States who cooperated in bringing it about. It was a tribute to ingenuity, industriousness and patriotism.

But we have only started. The fine records Mr. Nelson and General Porter have generously applauded will seem quite unimportant a few months hence when the enemies will feel the full force of our chemical program.

RUBBER AND RUBBISH

ELLIOTT E. SIMPSON, the "independent" rubber man who recently announced that there are still millions of tons of scrap rubber lying around in the United States, is out to prove to the world that there is really no rubber shortage. It is merely a "myth" because (1) the stockpile of crude rubber in the United States is the greatest in history, (2) the Western Hemisphere contains many times more crude rubber in mature trees ready to be tapped than is available in all the trees of the Far East; (3) there are 200,000 sq.mi. of guayule bushes growing wild in Mexico besides a new domestic bush that can be grown any place in the south and can produce rubber in six months, (4) the United States has vast quantity of rubber extenders and chemicals cheaper than any other country in the world, and (5) synthetic rubber plants can be built to process rubber out of petroleum and alcohol available in greater abundance here than anywhere else in the world. Mr. Simpson wants it understood, of course, that he is in favor of the government's synthetic rubber program—"but only as good insurance." Against what, he doesn't say, but presumably it must be the "interests" that have been keeping the foregoing "facts" so secret.

Who is this learned man with such amazing information? He is the duly accredited and paid council of the Subcommittee of the United States House of Representatives Committee on Coinage, Weights, and Measures which is investigating the rubber situation! Having obtained the services of such a well-informed investigator there would seem to be no need for the subcommittee to hold hearings. Its members can now sit back and wait for Mr. Simpson to write his newest version of "Alice in Wonderland."

O.C.D. CHANGES THE SIGNALS

JUST before the representatives of the American Institute of Chemical Engineers were to go on the air the other evening to discuss "Protection Against Incendiaries and Poison Gas," word came from Washington that our script would have to be

EDITORIAL VIEWPOINT

changed. It seems that recent research by the Chemical Warfare Service, confirmed by later experiences in Great Britain and New Zealand, had convinced the Office of Civilian Defense that it was all wrong to spray a burning bomb of the thermit-magnesium type. The new procedure called for a "direct jet of water"—a full stream from the garden hose rather than the coarse sprinkle of the stirrup pump. It emphasizes speed rather than precision as the quickest and surest way of putting the bomb out of action. After all, the fire that the bomb may start is more dangerous than the bomb itself. Only where highly flammable material may be sufficiently near the bomb to be ignited by the scattering of the burning magnesium, is the coarse spray recommended. Sand or other smothering agent is to be used "only if a bomb falls where it is not likely to start a fire, or if water is not available."

All this, despite its logic and directness, is just a little bit confusing. Thousands of air wardens have been giving lectures and reading articles and pamphlets based on several years of British experience. Many of us have witnessed very effective demonstrations of the older method. On the walls of the very N.B.C. studio in which we made our broadcast were explicit instructions to avoid a full stream while carefully spraying the burning bomb. But all that is now as obsolete as the various "standard" and "approved" types of spraying accessories we have all been urged to buy. Times have changed and, we hope, for the better.

INDUSTRIAL FIRE FIGHTING

Fortunately no such fickleness characterizes the accepted rules and practices of fire prevention as developed for the protection of industrial property. Over a period of years, chemical industry has established a fine record in the face of serious fire and explosion hazards that are inherent in its processes and products. Now, more than ever before, there is need for caution, careful study and effective procedures for fire fighting as well as its prevention. The sort of information that we have concentrated in this month's report (see pp. 99 to 104) should be part of every chemical engineer's knowledge and equipment.

WASHINGTON HIGHLIGHTS

Shortages of raw materials have become so severe that they are limiting war production in many lines. The situation will become worse before it gets better. Certain manufacturers are a bit worried over the reaction of labor when hours are cut down and incomes reduced by inability to get sufficient material for full-time operation.

No relief is yet in sight. In general, the country has more than enough fabricating capacity in many lines to absorb all of the materials available, and more. Someone has to say who is to receive materials and who will not. That's what decided the cancellation of the Higgins shipbuilding contract. It's also the major consideration in the synthetic rubber program.

Control of purchasing started a related controversy that hasn't yet been settled finally. The real issue at stake is whether the country's economy during wartime is to be run by civilians or by the military establishment. To date, the President is backing Don Nelson, but pressure from the military is enormous. The new WPB setup has got to work—or else.

Ship bottoms are still the critical, limiting factor, but despite reports to the contrary, no serious delays have been experienced in shipping the actual munitions of war to our allies. Tonnage available has improved during the last month to the extent that ships formerly carrying non-essential goods have been diverted to carrying war goods, and cross-hauls are being eliminated.

No electric power rationing is anticipated this year. For the first time in years the utilities, through the power section of WPB, have a neutral agency in Washington through which they may deal in planning expansion, interconnections and other steps necessary to make the most of the power resources we already possess. With the 5,000,000 kw. now projected, no critical power situation is visible anywhere on the horizon.

How One Chemical Concern Now Meets the War Emergency

JOHN R. CALLAHAM

Assistant Editor, Chemical & Metallurgical Engineering

Chem. & Met. INTERPRETATION

Here is the story of how one enterprising chemical company which, when it found its regular source of purchased phenol raw material threatened by shortages caused by the war, used its chemical initiative and engineering ingenuity to erect and equip with a minimum of expense and time a plant to manufacture this raw material. Reconditioned equipment and non-critical materials of construction were used whenever possible, and work was principally done by the concern's own engineering personnel and shop facilities. —*Editors.*

In the Fall of 1941, the Catalin Corp. of America, long a major factor in the manufacture of cast phenolic resins, realized that the shortage of phenol raw material for these resins was rapidly becoming critical. Officials of the company foresaw that within a few months it would be almost impossible for them to purchase any phenol at all.

In a series of executive conferences, it was decided that the company should manufacture its own phenol. This decision seemed rash, for at that time priorities on new equipment and machinery made it almost impossible to build and equip a plant within any reasonable time. The use of reconditioned equipment and non-critical materials picked up from various sources was the only alternative. As for the process, it was decided that the sulphonation of benzene would, under the circumstances, be most simple and feasible and require the minimum of equipment.

Phenol plant of the Catalin Corp. located at Matawan, N. J. The unit to the right was acquired from U. S. Tar Products Co.

Accordingly, early in October the Catalin Corp. of America acquired certain buildings and facilities from the plant of the U. S. Tar Products Co. located outside Matawan, N. J. By the middle of October, construction was under way on new buildings to be used in conjunction with existing units. Meanwhile, reconditioned equipment was being picked up whenever and wherever available and modified to fit the processing needs at the company's maintenance shop located at Fords, N. J. Some equipment designed for other uses was converted and installed even before the final building was completed. Probably as much as 75 percent of the total equipment requirements were obtained from used machinery sources, as indicated in the accompanying flowsheet.

All engineering work, plant layouts, equipment reconditioning and installation of apparatus was done principally by the company's own personnel. Erection and successful operation of the synthetic phenol plant represents a considerable achievement, since the company had the time to conduct only very preliminary experiments and had little previous engineering experience with the process. No pilot plant or even large-scale laboratory work was conducted prior to erection of the plant.

By March of 1942 the plant was in production. Since that time it has continued to supply substantial phenol requirements of the company with a minimum of operating difficulties and delays.

COST AND CAPACITY

Total cost of the present plant has been estimated at less than half a million dollars. Officials of the company concede that only a war-time economy has made worthwhile the erection of the plant and use of this particular process. Considerable refinement and process improvements are contemplated, however, and operations will be continued even after the chemical world returns to normalcy. Meanwhile, however, the company continues to get considerable phenol and manufacture its regular line of phenolic resins for various essential uses.

Rated capacity of the plant has been placed at several hundred thousand pounds of U.S.P. phenol per month, representing several percent of the estimated total domestic phenol production for 1941. The plant operates seven days per week and employs a total of about 30 operating personnel for three shifts.

PROCESS USED

In brief, the process consists of the treatment of nitration grade benzene with oleum to produce benzene sulphonic acid, which is neutralized with sodium sulphite. The sodium salt thus formed is fused with caustic soda and the mass treated with water, yielding sodium phenate and sodium sulphite. The solid sodium sulphite is filtered off for re-use and the sodium phenate is acidified with sulphurous acid to give a crude phenol which must be distilled under vacuum to produce the U.S.P. product.

Primary raw materials for the

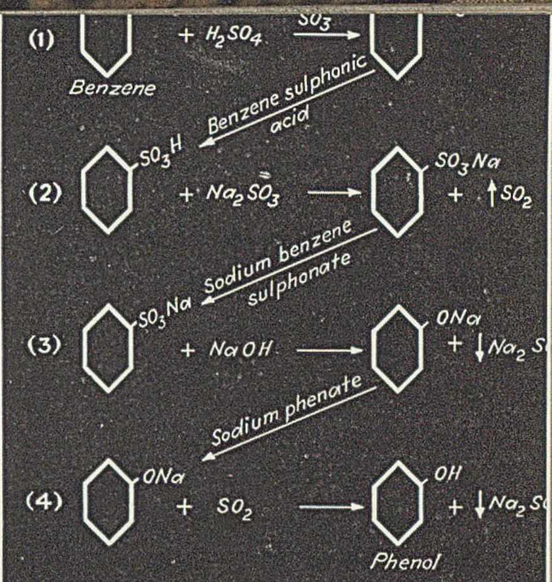
process are nitration grade benzene and 20 percent oleum. Previously, 26 percent oleum had been used, but trouble was experienced with the freezing of this material. Reconditioned riveted unlined steel gasoline tanks, housed in a separate building for safety, are used as storages for both benzene and oleum. Each of the two benzene storages holds 1½ tank cars of benzene, and each of the two oleum storages holds 1½ tank cars of acid. Oleum lines are lagged and traced with steam lines to prevent freezing, and benzene is handled by bronze pumps through iron lines for safety purposes. Pumps and valves throughout the plant are largely second-hand.

SULPHONATION PHASE

Sulphonation is carried out in a separate new building with a concrete bottom floor and wooden half-floor. Sulphonation tanks are shown in an accompanying photograph. This building is outstanding for its cleanliness and the precautions that have been taken to eliminate fire hazards. These include explosion-proof motors on the sulphonation units, fire blankets, and portable carbon dioxide fire extinguishers.

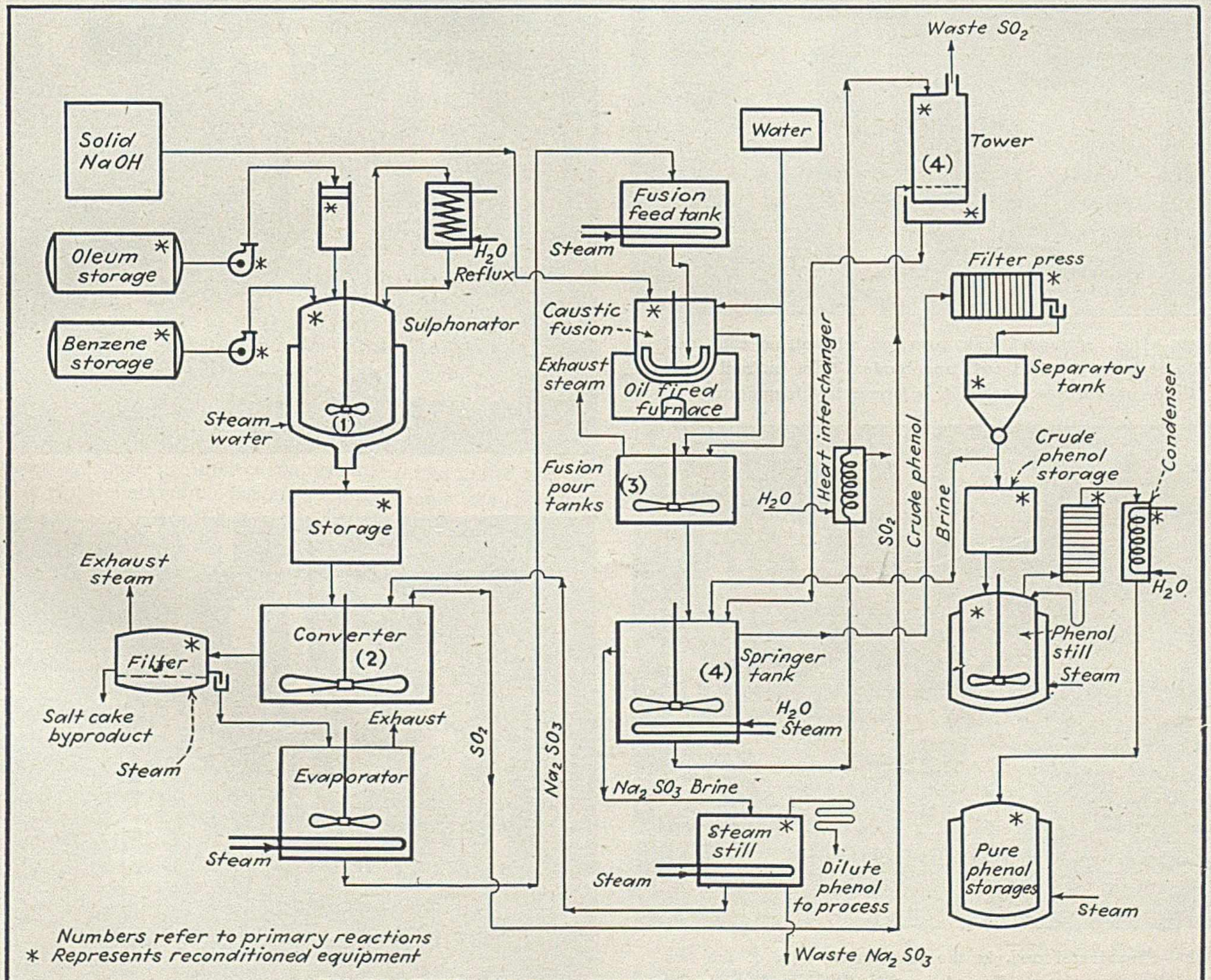
The two sulphonation kettles, each of 600 gal. capacity, are both of cast iron construction provided with 400 r.p.m. agitators of the propeller type. The units are unlined and are reported to have been used previously in the manufacture of shoe polish. The bottom half of each of the sulphonators has been jacketed at the company's Fords shop to provide for steam of 80 lb. pressure. Each reactor is provided with a benzene reflux tank equipped with cooling coils.

Benzene is metered into the kettles, while the oleum is fed into calibrated vessels formerly used as air compressor tanks. The full charge of benzene is first added at room temperature. Oleum in excess of that necessary for

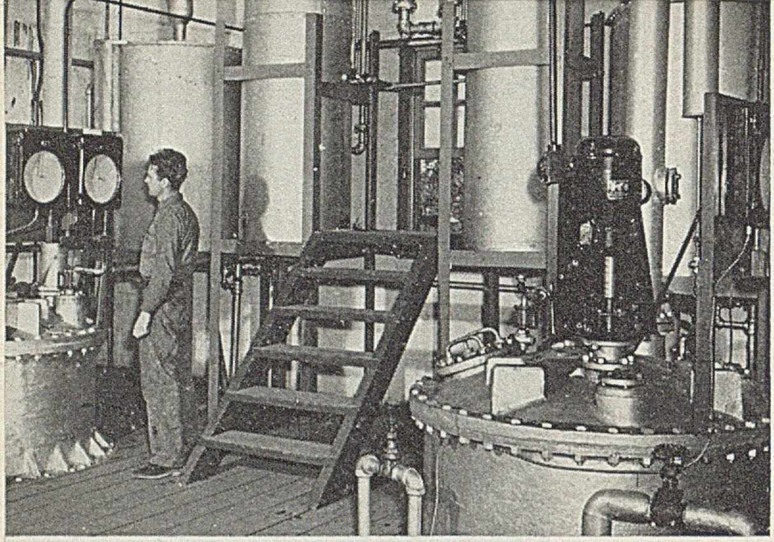


PRIMARY CHEMICAL REACTIONS
(Refer to flow sheet for location of each reaction

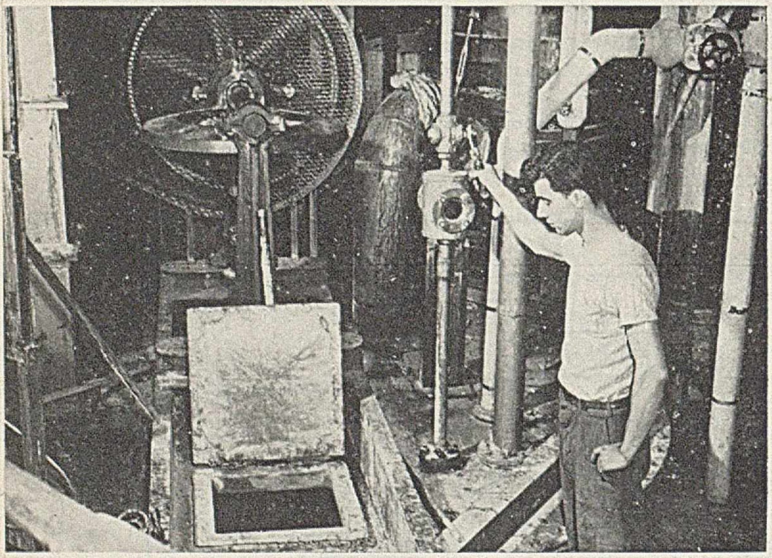
The above equations show the primary reactions in the phenol process used by the Catalin Corp. Side reactions are not shown, nor are equations stoichiometric. The flow sheet below shows each step



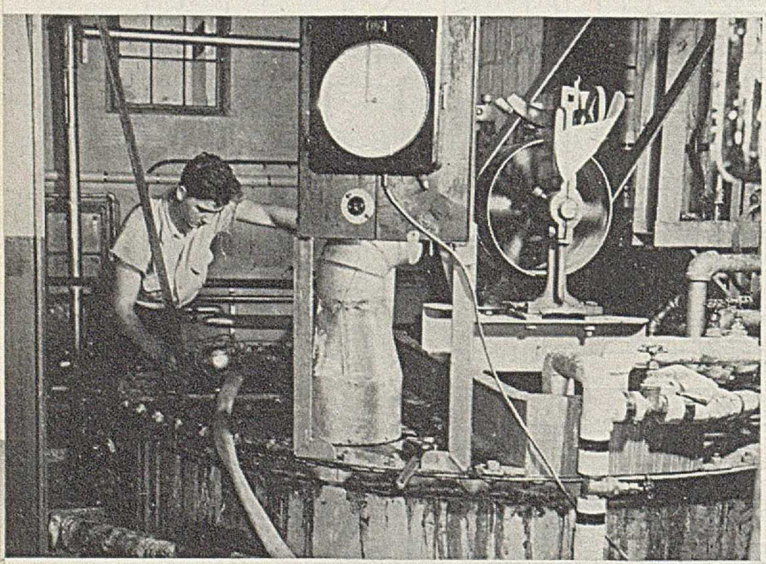
SIMPLIFIED FLOW SHEET OF OPERATIONS



Below—Converter tank, which is steel lined with lead and then with acid-proof brick. Here benzene sulphonic acid is neutralized with sodium sulphite to liberate sulphur dioxide



Below—This "springer" tank, provided with steam coils and a stirrer having bolted cast iron blades, is of unlined steel. Crude phenol (see reaction 4) is formed in this apparatus

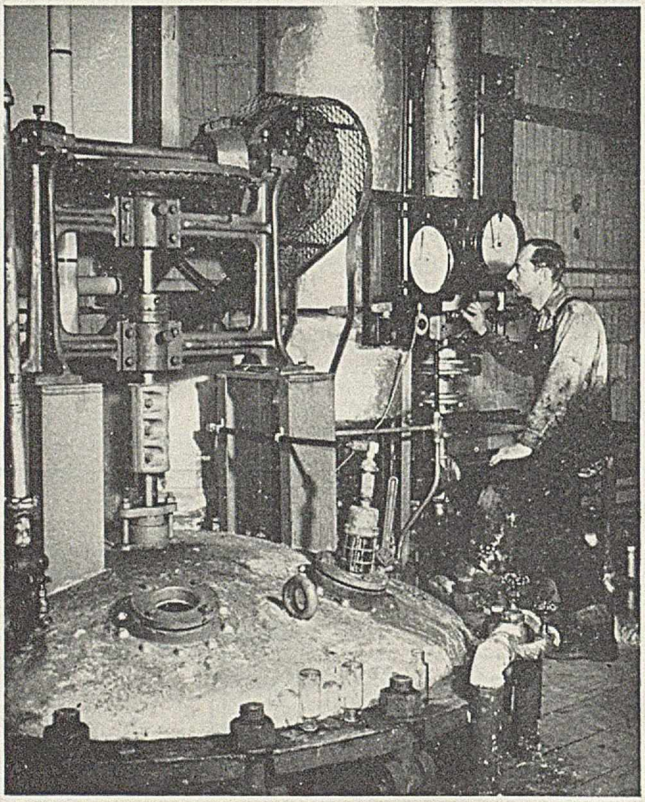


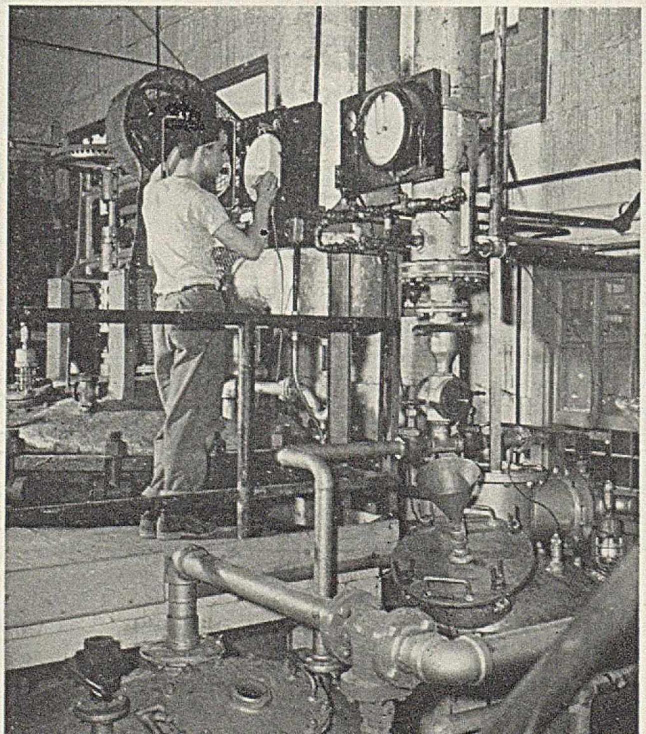
Right—Phenol still and, in the foreground, tops of the two pure phenol receivers. One of these is nickel-lined, while the other is glass-lined. Both were formerly used as resin kettles

Left—Tops of the two benzene sulphonation kettles, showing temperature recorders, benzene reflux units and oleum feed tanks. Sulphonators are unlined, cast iron vessels formerly used for the preparation of shoe polish

◆

Below—This reconditioned, jacketed still is of unlined steel construction. Phenol vapors pass upward through the fractionating tower to the right, which is packed with Berl saddles and provided with a dephlegmator and condenser





the reaction is then fed in slowly over a period of several hours. Since the reaction between benzene and oleum liberates a considerable amount of heat (110 B.t.u. per lb. of reactants) it is necessary to add the oleum carefully and even at times to pass cooling water through the jacket so as to maintain the temperature of the reactants at about 95-105 deg. F.

BENZENE SULPHONIC ACID

When the heat of reaction has been absorbed, steam is added to the jacket and the mass heated until the final temperature is at 250-265 deg. F. Unreacted benzene starts to reflux and the reaction is complete in 2-3 hours. The reaction product, benzene sulphonic acid, has a specific gravity of 1.45 at 68 deg. F. and will solidify at room temperature. Hence it is necessary that lines to storage tanks be insulated and traced with live steam lines.

Benzene sulphonic acid, dark from iron impurities, is pumped from the sulphonation unit to the charging tank above the converter or "quencher", which is a steel tank lined with lead and then with acid-proof brick. Sodium sulphite from the following operation is added to the benzene sulphonic acid to form sodium benzene sulphonate, with the liberation of sulphur dioxide. Excess sulphuric acid from the sulphonation reaction forms sodium sulphate with part of the sodium sulphite. This reaction occurs first, after which the benzene sulphonic acid is reacted upon. The reaction is carried to neutralization, which requires 10-14 hours for completion. It is expected that this cycle will soon be shortened. No freezing must be allowed to occur. The mass contains 60 percent water.

Sulphur dioxide liberated at this point of the process passes up a stoneware tower packed with Raschig rings and flows counter-current to sodium phenate solution.

SALT CAKE BYPRODUCT

Slurry from the converter containing precipitated sodium sulphate and sodium benzene sulphonate is pumped through a pressure filter for removal of the sodium sulphate. This filter tank, formerly used in the manufacture of beer, is of steel construction and is provided with a wire screen filter upon which sodium sulphate builds up to a cake of 2-3 ft. in thickness. When sufficient cake has been built up, it is then steamed for several hours to volatilize residual sodium benzene sulphonate. The moist salt cake is removed manually by rakes and shoveled into a chute to the outside of the building.

Final characteristics of the salt cake are dependent primarily upon the time at which it is removed from the press. If it is removed while still hot and moist, the final cake will be granular and friable, while if it is allowed to cool in the press, it then becomes compact and hard. This salt cake carries the iron impurities precipitated with the converter slurry.

Filtrate from the pressure filter, containing the sodium benzene sulphonate, is then pumped to one of two evaporators, where the water content is lowered to about 50 percent by the use of steam coils. It is then pumped to one of two feed tanks above the caustic fusion pots. These feed tanks are provided with steam coils to prevent solidification.

CAUSTIC FUSION

The caustic fusion pots are redesigned cast iron vessels provided with horseshoe type agitators. They are heated at 610-660 deg. F. directly by two oil-fired furnaces and the solid caustic melts slowly for 2-3 hours. Process water is first added and then the sodium benzene sulphonate solution is fed slowly into the hot fused caustic to form sodium phenate and sodium sulphite. Evolved steam is vented to the atmosphere. The sodium phenate formed goes into solution while the sodium sulphite remains undissolved, since excess caustic soda serves to depress the solubility of sodium sulphite. The slurry of sodium phenate solution-sodium sulphite solid-excess caustic soda from the fusion pour tanks is pumped to one or two "springer" tanks. These two units are of steel construction and are provided with water and steam coils and a stirrer with bolted cast iron blades. They are also equipped with a heat exchanger tank for cooling the phenate charge.

Springer tanks, the quencher or converter and the SO_2 reaction tower are all operated in conjunction. Sulphur dioxide generated in the converter enters into the bottom of a stoneware tower approximately 12 ft. high and 3 ft. in diameter and packed with Raschig rings. The SO_2 flows upward counter-current to the springer liquor, which is pumped in at the top. This liquor, consisting of sodium phenate solution, solid sodium sulphite and excess caustic soda, is gassed by circulation through this tower until the pH has been lowered from about 11-12 at the beginning to 7.25. At this stage all of the sodium phenate has been converted into crude phenol, with formation of Na_2SO_3.

After the conversion is completed, pumping is ceased and the slurry is allowed to separate into three distinct layers. The first and top layer consists of dark brown crude phenol of about 85 percent strength. The second layer consists of straw-colored saturated sodium sulphite brine, while the bottom consists of white, crystalline sodium sulphite sludge.

The top layer of crude phenol is drawn off, passes through a second-hand filter press to remove any solid sodium sulphite, and then goes into a small crude phenol separatory tank. The bottom of this is conical and is provided with a valve and sight glass. The crude phenol and brine are here easily separated, since there is a clear line of demarcation between the dark brown phenol and the straw-colored brine. The brine is pumped back to the springer tank is to be recycled.

PHENOL DISTILLATION

From the separatory tank, the crude phenol goes to a used storage tank from where it is pumped to the phenol still. This is an unlined steel tank provided with a cast iron blade agitator and jacketed. Phenol is distilled off under vacuum and passes upward through a small fractionating tower packed with Berl saddles to separate the phenol from water. This tower is provided with a dephlegmator at the top and is followed by a small stainless steel condenser tower.

Located near the phenol still are the two pure phenol receivers. One of these is nickel-lined, while the other is glass-lined. These were formerly used as reaction kettles for the manufacture of resins at the Fords plant of the Catalin Corp. These receivers have been jacketed at the bottom for heating to prevent solidification of the phenol, which is now of the U.S.P. grade. From here the final phenol product is pumped to storage tanks, where it is ready for shipment.

Sodium sulphite slurry from the springer tank is sent to the steam still, another used piece of equipment, where it is steamed to drive off dilute residual phenol, which is returned to the process. The sulphite slurry is recycled in the process and returns to the converter for reaction with benzene sulphonic acid. Part of the excess sodium sulphite from the operations is marketed.

The writer would like to thank Mr. W. R. Thompson, technical director, and Mr. V. W. Moss, plant chemist, for their ready assistance and for aid in providing information contained in this article.

Combating Chronic Poisoning in Chemical Operations

WILLIAM M. PIERCE
Supervising Chemical Engineer, Employers' Liability Assurance Corp., Boston, Mass.

Chem. & Met. INTERPRETATION

In many plants the chemical engineer is called upon to pass judgment on the hazards which may result from the use of a certain chemical. These opinions are generally sound insofar as corrosion, explosions, contamination of product or acute poisoning are concerned. However, the probability of chronic poisoning is often ignored by many technical men. This may be due to faulty training as well as to the concentration of industrial hygiene literature in journals not widely read by chemical engineers employed in industry. —*Editors.*

Hazards of chronic exposure are hidden, difficult to detect, and the effects, besides requiring considerable time to develop, are greatly masked by individual differences in susceptibility. Yet it is chronic poisoning that is typical of the exposures encountered in industry, whereas technical and research men are usually exposed to poisoning of an acute nature. The employee working on an industrial job will be exposed to more or less the same conditions for years. On the other hand, the man doing experimental or research work may remain with one material only for a few weeks or a month. In many cases the man who has done development work assumes from his apparently short exposure to relatively high concentrations that the material in question is harmless. This premise may not be justified, since he may be particularly resistant to the material or there may not have been enough time for the development of chronic poisoning.

SPOTLIGHTING DANGERS

Something is necessary to make the hidden dangers of chronic poisoning stand out, for if the danger is recognized the hazard is already partly controlled. One recent development in accident prevention involves the spotlighting of danger points on machines by the use of color contrasts. A light color is used on and near the tool area and a darker shade for the remainder of the machine. The operator works more efficiently and with less hazard because the lighted tool area concentrates his attention on the work and also spotlights the danger spot. This color contrast alone has been sufficient to decrease the accident rate by 70 percent. Such results indicate the importance of calling attention to hazards and putting the spotlight on them. In the case of chronic poisons, it is difficult to detect the hazards except by chemical or physical means. There is usually no warning to the people who may be exposed.

Benzene poisoning is a hazard of this type. Even the name tends to conceal the danger since the material benzine, which is often confused with it, is comparatively non-toxic. Serious benzol poisoning may occur on jobs where men have worked for months without any discomfort or warning of any kind that they are exposed to dangerous fumes. Apparently without any reason, the accumulated effects of the exposure appear in the form of an anemia which is extremely difficult to treat. Even if the victim lives, he may never completely regain normal health.

Such chronic cases of poisoning, although much less spectacular, are more numerous and more serious than acute cases. The damage from repeated small doses of lead over a period of a year is more serious than that done by one short exposure to a very large concentration. Acute exposure produces serious effects and discomfort, but does not leave anywhere near the same amount of permanent damage.

There are comparatively few cases of industrial poisoning from materials such as ammonia, sulphur dioxide or hydrogen sulphide. This is because these materials are so disagreeable and so irritating that workmen are careful regarding their exposure. Cases are also rare with violent poisons, such as hydrogen cyanide and carbon monoxide. These materials are extremely poisonous and have very marked acute effects. Knowledge of their properties is widespread and precautions are usually taken wherever there is a possibility of exposure. The comparatively small number of cases occurring from hydrogen cyanide and from carbon monoxide, considering the danger, is very encouraging. It indicates that adequate knowledge in the hands of people who might be exposed will go a long way toward controlling the hazard. It is of utmost importance, therefore, that knowlledge regarding the possibility of chronic poisoning should be brought to the attention of the people who will be exposed to these materials as well as to those who design equipment for use with these chemicals.

INHALED POISONS

There is a considerable difference between the poisonings which occur in ordinary life and those which usually occur in industrial plants. Outside industry, most poisons get into the body by being swallowed. In industrial exposures the poisons are generally inhaled. There is quite a difference in the action of a poison, depending on whether it is swallowed or breathed. If a small amount of toxic substance is swallowed, there is a good chance that it can pass through the digestive system and out

This is the first of a series of articles designed to acquaint the chemical engineer with the hazards and prevention of chronic poisoning in industrial chemical operations. Other installments will deal specifically with heavy metal poisons, fibrosis-producing dusts, and toxic solvents.—*Editors.*

through the intestines with only small amounts being absorbed. This is particularly true with comparatively insoluble materials, such as lead. In the case of large amounts of poisons, the material may be rejected by the stomach. It is also possible that if some poison is absorbed the blood may be partially purified of the material in passing through the liver.

Thus, in ingested or swallowed poisons, some of the material may pass through the body unabsorbed so that all of the substance taken in does not necessarily contribute to poisoning. This, of course, does not hold for a soluble material such as sodium cyanide.

Dust fumes or vapors breathed into the lungs can only escape without absorption by returning the way they entered. Some of the material may lodge in the back of the throat and be swallowed. If the dust is very fine, a good portion of it may be breathed out again. However, the portion remaining in the lungs may be absorbed directly into the blood, which goes from the lungs to the heart and from that organ to every part of the body without first having to pass through the liver. It is apparent, therefore, that small doses which are inhaled are more apt to come in contact with the various organs of the body and to cause greater effects than materials which are swallowed.

Recognition of the dangers from inhaled dusts has contributed a great deal to the control of lead poisoning. For a number of years considerable emphasis was placed on personal cleanliness on the part of lead workers. Every possible source of lead ingestion was eliminated. Men were required to wash before eating and to take showers on leaving their jobs. They were also required to change their clothes and, in general, take any and every precaution to prevent any lead entering the body by the way of the mouth. The results from this control produced a very marked decrease in the number of lead poisoning cases. However, on certain jobs, lead cases continued to occur. With the recognition by lead companies that inhaled dusts were also very important and should be controlled, the number of cases fell off very rapidly.

INDIVIDUAL DIFFERENCES

One reason why engineers are often lulled into a sense of false security regarding certain materials is the fact that they may personally have worked with some of these materials for years without any ill effects. However, certain people are affected by drugs or poisons much more than others. A good example of this is the reaction that a group of people will obtain from drinking the same amount of alcohol. Certain people are affected by ragweed pollen; others are allergic to shellfish or strawberries, and others may have asthma when they come near a horse or a dog. It is difficult to explain these differences between individuals. We know, however, that of several men working on the same job and exposed to the same hazards, one may die and the others may not be affected at all.

A very interesting report which brings out this difference has been made by Captain Dudley of the British Navy. There were a number of cases of arsine poisoning on a submarine as a result of gas given off from the storage battery, the grids of which contained 0.2 percent arsenic. On one trip, 56 men formed a crew. Of this number, 30 were sent to the hospital, 15 were sick for a few days, 10 had very mild symptoms. One man did not feel any reaction. All of the men were exposed to the same amount of fumes for the same period of time. All of these sailors were presumably in good health and, considering that they were on submarine service, a picked group physically. However, the effects varied from the man who did not suffer any ill effects at all to one who was completely incapacitated for a short time. In some cases it was nearly six months before the blood count was up to normal.

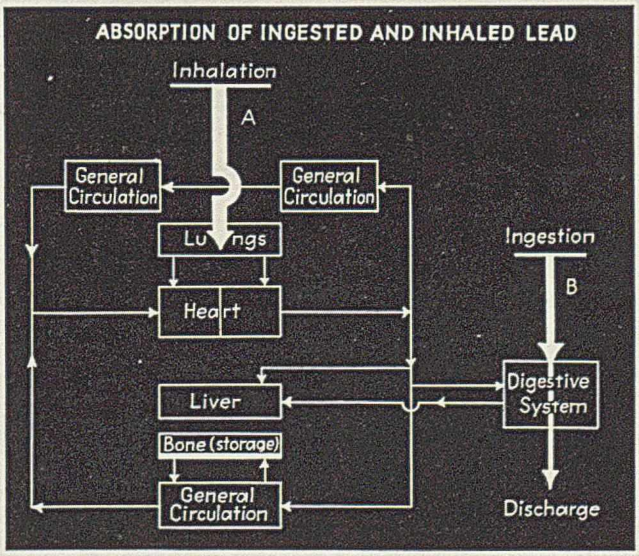
There is also a case on record where four men were caught for a few minutes in a room full of ammonia fumes. One of these men died 15 minutes later, one man died after 24 hours, the third lived until the next day, and the fourth recovered completely.

In industrial exposures, it is very important to protect the most susceptible individuals. Some people are inclined to feel that if one man out of six or seven is affected by a given operation, then it is the individual's fault and no action is necessary to protect against this particular hazard. If it were possible to pick out the men who are resistant to a given poison, this attitude might then be justified. It can easily be shown experimentally that animals show differences in susceptibility to poison, but these differences cannot be attributed to personal habits.

CONTROL OF HAZARDS

In the control of lead poisoning, for example, some manufacturers have taken into account this difference in individual susceptibility. On jobs where the lead exposure might be near the borderline, blood examinations are made at periodical intervals to detect signs of lead absorption. This is detected by changes in the structure of certain of the blood cells. The initial indication of absorption does not mean that the operator has lead poisoning, but that a certain amount of lead is being absorbed into the system and that he should be removed from the exposure before definite symptoms develop. The same type of control is used in connection with benzol, where examinations of the urine will detect absorption of the material. In this way men can be removed from the exposure or conditions can be improved as soon as signs of absorption are encountered.

(*Please turn to page* 93)



Motorizing Equipment in Hazardous Locations

C. W. FALLS *Engineer, Motor Division, General Electric Co.*

The necessity for speed in equipping plants for war purposes precludes development of special designs. Therefore, the chemical engineer who has the problem of motorizing plants producing or processing hazardous materials will find of value the author's suggestions and comments on the adaptability of standard types of motors that have been designed for somewhat similar conditions.—*Editors.*

The tremendous expansion of plants for manufacturing and handling explosive substances has swelled the demand for motors to be used in hazardous gas and dust locations. The technical literature in the past year or two has covered processes and materials involved in the manufacture and use of some of the more important military explosives, however, little has been published about the proper application of motors in hazardous areas of such plants. The best means of motorizing ammunition plants with types recently developed for somewhat similar conditions is a definite problem.

In some of these new plants the hazardous areas involve different substances presenting questions of selection of proper types of motors or decisions as to plant layout and motor location. An important factor in obtaining continuous operation, which is essential to the war effort, is the selection of motors suitable for the particular hazard involved. Motors must not be used in areas involving explosive conditions beyond the scope of their designs.

The more hazardous locations in ammunition manufacturing and handling plants, as well as those plants which produce chemical raw materials, may be classified broadly as (1) those involving flammable gases or flammable volatile liquids and (2) those in which highly explosive or combustible dusts are found. Such flammable gases and liquids, from which may come hazardous vapor-air mixtures, include acetylene, ether, hydrogen, acetone, alcohols, toluol, benzol and various petroleum products. Among the explosive or combustible dusts are starch, sulphur, powdered aluminum, magnesium, smokeless powder, and black powder.

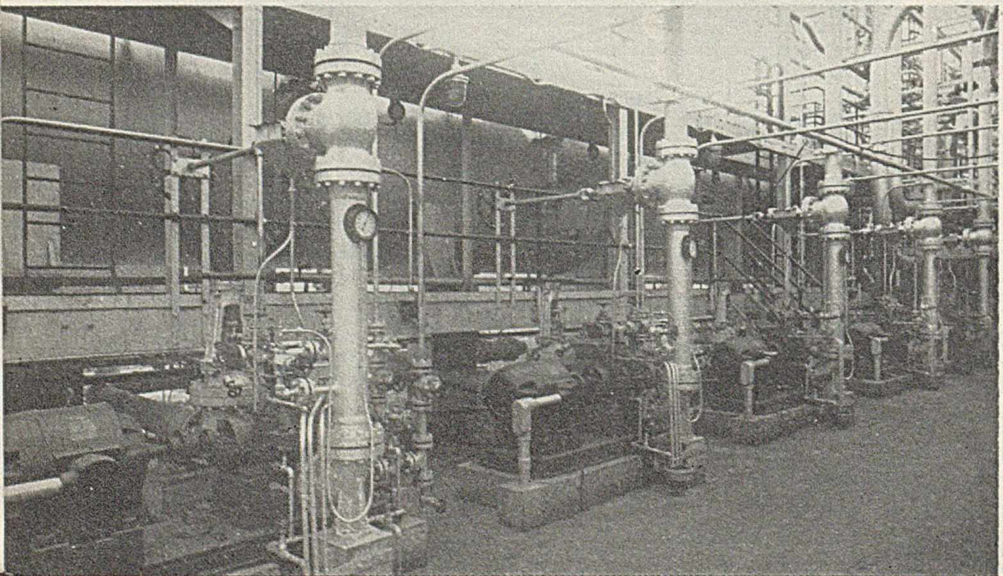
Some of these substances are definitely beyond the ability of the available motor designs, while others are well within the limits of present-day equipment. In the case of many of these substances, the successful use of motors within the hazardous areas is not particularly a matter of motor design, but depends largely upon the users' attention to such factors as: (1) avoidance of accumulations of the hazardous material on the motors, (2) selection and careful maintenance of proper types and sizes of overload relays, (3) proper layout of the distribution system, and (4) choice of breakers with adequate interrupting capacity.

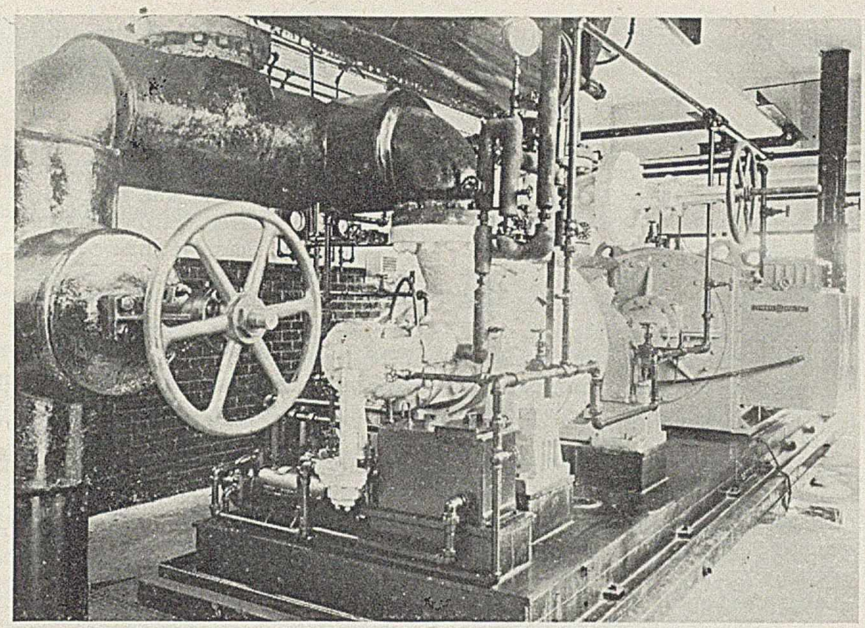
The necessity for speed in the erection and operation of these plants for war purposes has precluded the possibility of lengthy tests leading to the development of special motor designs best suited for each of the hazardous materials involved. It has been necessary to utilize the best motors available, in many instances using special arrangements of location or ventilation. In order to permit the most intelligent selection and application of available types of motors and to reach the best solution of the problems involved, particularly where new hazardous materials appear, it is necessary to have an understanding of the design objectives, construction features, and tests for suitability of the various types of motors for these plants.

The most obvious solution, but one which cannot always readily be carried out, is isolation of motors by locating them outside of the hazardous area so that they will not be exposed to the danger. This has been the practice for many years in parts of powder mills, particularly for the "corning" or "granulating" process where the driving motors have been located behind earthen barriers outside of the process buildings. In areas involving materials which have ignition temperatures approximating the normal operating temperature of the motors and where accumulation of the material on the motors cannot be prevented, isolation by walls, partitions, or enclosures of some sort is indicated.

Similarly, isolation is needed for hazardous areas involving gases, such as acetylene, that upon explosion may produce pressures of an order much higher than those for which industrial motors have been designed. This is also true in the case of gases like carbon disulphide, the ignition temperature of which approaches the normal operating temperature of a motor. Even though the motors are remotely located, it is usually good practice to use one of the totally en-

Explosion-proof motors each coupled to centrifugal pump operating out of doors in Texas oil refinery





Hot-oil charging pump in oil refinery driven by inert-gas-filled squirrel-cage induction motor with built-in heat exchangers

closed types as a means of minimizing the fire hazard.

It is not always feasible or practical to locate motors remotely or to isolate them from the driven machine and surrounding hazardous area. The nature of the driven machine and the desire to eliminate certain intermediate mechanical driving devices may call for locating the motors on or very close to the driven machines. There are several types of enclosed motor construction which are usually suggested for these applications. They include such constructions as (1) pipe-ventilated motors, (2) inert gas-filled motors, (3) totally enclosed Class II motors, and (4) Class I explosion-proof motors.

The National Electrical Code Classifies Hazardous Gas and Dust Locations as follows:

Class I, Group A, atmospheres containing acetylene;
Class I, Group B, atmospheres containing hydrogen or gases or vapors of equivalent hazard such as manufactured gas;
Class I, Group C, atmospheres containing ethyl ether vapor;
Class I, Group D, atmospheres containing gasoline, petroleum, naptha, alcohols, acetone, lacquer solvent vapors, and natural gas;
Class II, Group E, atmospheres containing metal dust;
Class II, Group F, atmospheres containing carbon black, coal or coke dust;
Class II, Group G, atmospheres containing grain dust.

Pipe-ventilated motors are relatively limited in their effectiveness for application in hazardous locations. Usually they simply are enclosed motors with air intakes and outlets arranged for accommodating pipes for ventilating air. When flammable gases surround the motor, gas accumulations and possible explosions on the inside may be prevented by passing clean air through it. Pipe ventilation obviously does not prevent accumulation of hazardous material on the outside surfaces of the motor frames and piping. Therefore, the heating of the motor under normal and abnormal load conditions must be considered. Furthermore, automatic fire extinguishing equipment within such motors and perhaps within the air ducts may be necessary to subdue internal fires and prevent heating of the exterior of the motor frame and piping.

Inert gas-filled motors, which are enclosed motors with auxiliary equipment to maintain gas under slight pressure within the enclosures, have been found useful in hazardous gas locations. Such motors in sizes above 400 or 500 hp. are particularly useful where it becomes increasingly difficult to obtain totally enclosed, fan-cooled explosion-proof motors. The enclosures are tight enough to require only a small supply of "make-up" gas, and the pressure prevents entrance of surrounding hazardous gas.

Enclosed Class II motors for use in combustible or explosive dusts are of totally enclosed construction, with or without fan cooling. Such motors are designed on the assumption that it is practical and relatively easy to make machines dust-tight and hence, dust explosions within these motors will not occur. Such motors also should be designed so that no external parts will spark or overheat under permissible overloads to the extent of igniting surrounding dust.

These design objectives have been obtained in motors for Class II, Group G, dust conditions by the use of tight joints with at least 3/16-in. metal-to-metal surface contact, also close clearances of bearing housing lips along the shaft, permanently sealed-in leads, nonsparking external fan material, relatively straight and smooth external ventilating passages (of fan-cooled motors) to prevent rapid clogging and to facilitate cleaning. The normal operating temperature of the motors in the usual ambient and with permissible overloads, is well below the ignition point of the specified dust.

It will be noted that Class II motors for combustible dusts are not necessarily explosion-proof, since it is possible to obtain dust-tightness as well as meet the other design objectives by relatively thin enclosing parts. It is true, however, that several motor manufacturers have taken advantage of their explosion-proof Class I motor development and simply submitted explosion-proof motors for dust tests rather than attempt a separate line of motors.

Tests for suitability of motors for Class II dust conditions are carried out by placing a motor in a test chamber and subjecting it to dust-air mixtures while the motor is alternately heated and cooled by loading and unloading. Cycles approximating several years of operation in an industrial plant are carried out before disassembly to observe whether any dust has entered the enclosure.

A second test is made in the same dust chamber for the purpose of determining whether the temperature attained when the motor is blanketed with a specified dust will be high enough to produce serious charring or ignition of the dust. Tests are conducted under full rated load, temperatures being measured by thermocouples and the dust in contact with the enclosure being examined for evidence of charring or ignition.

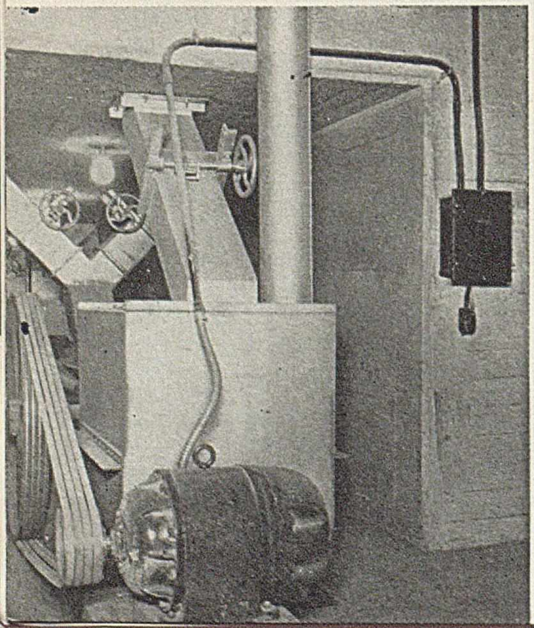
Tests of this sort have been carried out on motors as large as 400 hp., 1,800 rpm., to determine their suitability in grain dust (Class II, Group G) of the fineness found in elevators and similar locations. These motors have successfully passed such tests but their successful use for grain dust is predicated on proper maintenance to avoid excessive accumulations of dust on the motors, and particularly upon the selection and maintenance of suitable relays and short circuit protective devices to disconnect the motor immediately in case of excessive overloads, single phasing, or stalling.

Tests have also been carried out on designs of enclosed motors to determine their suitability in magnesium dust. As a result polyphase induction motors as high as 100 hp., single-phase motors up to 10 hp., and d.c. motors up to 30 hp. are now available for use in magnesium and in aluminum dust locations.

Where dusts of explosives such as TNT, black powder, and smokeless powder are encountered, successful use of Class II motors, in spite of their dust-tightness, will depend almost entirely upon proper relays, and upon maintenance which will prevent accumulation of such dusts on these motors. If these precautions can not be carried out, remote location outside of the dust area is necessary.

Explosion-proof Class I motors are totally enclosed, with or without fan cooling, designed and constructed to withstand an explosion of a specified gas, and prevent the passage of dangerous sparks or flame from the interior to the surrounding atmosphere. It is considered impractical to make usual industrial motors tight enough to exclude gas. Therefore, it is assumed that explosions can occur within an enclosed motor through failure of a winding or where a bearing failure permits rubbing of the rotating member against the stationary member. Consequently, an explosion-proof motor requires that all of the enclosing parts shall be strong enough to withstand an explosion of maximum intensity within the motor. Furthermore, the external parts of the motor should not spark or attain sufficient temperature under expected operating conditions to ignite the surrounding atmosphere.

Totally enclosed, fan-cooled, ball-bearing squirrel-cage induction motors, for class 2, group G, locations, each V-belted to conveyor in grain elevator



These objectives are accomplished in the explosion-proof motors already developed for Class I, Group D, conditions by utilizing enclosing frames and end shields, strongly reinforced where necessary, to give ample factors of safety. Flanged joints giving wide metal-to-metal fits with small clearances are used as a means of cooling the flame from internal explosions. Bolts of strong material and closely spaced are utilized, and holes with removable plugs are avoided. Leads are sealed with a permanent non-shrinking compound of adequate strength and depth to withstand explosion pressures. Interconnecting compartments of free air spaces within the motor are avoided so that successive explosions with precompression and consequent high pressures will not occur. External fans of non-sparking material are provided.

The development of explosion-proof motors has centered around Class I, Group D, atmospheres encountered in refineries, chemical plants, and similar establishments. Actual explosion tests fully demonstrating the suitability of motors for such conditions have been made on sizes as large as 500 hp. and 3,600 rpm.

Tests for suitability of motors in explosive gases are made by subjecting the motors to the specified gas or vapor-air mixtures over the range of flammable or explosive concentrations, so as to cover the maximum pressure effects and the maximum propagation effects of the specified mixture. To carry out such tests a motor is installed in a test chamber provided with gas inlet and outlet connections. The motor is also tapped with threaded holes for connection of inlet and outlet pipes for the explosive mixture, also for spark-producing devices and pressure-recording instruments.

The explosive mixture of accurately determined proportions is allowed to flow through the motor as well as in the test chamber around the motor until all of the original air has been displaced. The inlet and outlet valves are closed and the mixture inside the motor ignited. Observations are made to determine the volume of flame escaping, and pressures are recorded. A minimum series of 15 to 20 tests is conducted over the flammable range with the motor running in some instances. Turbulence through fan action of the motor tends to bring about explosion pressures roughly proportional to the free volume inside of the motor-enclosing case.

Explosion-proof motors, designed and tested as described, have amply proved their usefulness in many hazardous atmospheres classified as Class I, Group D. These include acetone, alcohols, toluol, benzol, high-test gasoline, lacquer solvents, petroleum distillates, and many other substances.

Such motors are not generally usable in more hazardous mixtures involving acetylene, hydrogen, and ether. In some cases, the ignition temperature of the gas is too low for safe use. In other instances, the possible explosion pressures are too great and may necessitate different mechanical construction.

It is not always proper to assume that explosion-proof Class I, Group D, motors are dust-tight and suited for combustible dust conditions, although most manufacturers use dust-tight construction in explosion-proof designs.

Class I motors may be applicable in many of the preliminary stages of the production of explosives, for example TNT and smokeless powder, since the material then is in wet form and involves a considerable volume of solvent of the Class I, Group D, order. Obviously, where genuine Class I, Group D, hazards exist, explosion-proof Class I, Group D, motors are applicable.

In some instances, the solvent involved is ether, a Class I, Group D, hazard, involving lower ignition temperatures and higher explosion pressures. Except for the fractional-horsepower Class I, Group C, motors so far developed, the Class I, Group D, explosion-proof motors already in production no doubt are the best available for ether atmospheres, although not primarily designed for it. Obviously, no claim is made that they are suited for operation in ether atmospheres. Successful operation in ether will depend to a major degree on careful selection, application, and maintenance of overload relays which will prevent abnormal heating from any conditions of operation.

In subsequent stages of explosives manufacture, where the hazard changes from one of solvent vapors to a condition involving masses of somewhat drier, although not dusty explosive materials, remote location of the motors becomes necessary. This is principally due to the necessity for keeping heat-producing sources away from high explosives which might cause widespread damage if ignited.

Mg by Electrothermic Reduction

H. A. DOERNER, W. FLOYD HOLBROOK, E. DON DILLING, DWIGHT L. HARRIS

Metallurgical Division, United States Bureau of Mines, Pullman, Washington

Chem. & Met. INTERPRETATION

Recent research and development by the United States Bureau of Mines of the so-called Doerner process has attracted wide attention in industrial as well as in governmental circles. Originally conceived as part of a program to utilize the abundant magnesite resources of the Pacific Northwest, the present need for expanding the production of magnesium metal gives national significance to this work. The recent Bureau of Mines Report of Investigations 3635, May 1942, which is abstracted in these pages, is an important indication of the direction in which this research is progressing. It will be noted that the experimental work of these investigators has led to the design and preliminary operation of a continuous, small-scale pilot plant employing liquid hydrocarbons for the shock-cooling of the magnesium vapors. Operating data on both the units described in this article would seem to promise considerable reduction in both the costs and the hazards of processes dependent upon gas-cooling methods.—*Editors.*

The Bureau of Mines began a study of the various methods of producing magnesium metal from magnesites in 1936. The first work on this program was undertaken at Pullman, Wash. in cooperation with the State College of Washington. At that time the present need for expansion of the industry had not yet been felt; the study was prompted by the desire to establish a new metallurgical industry in the Northwest for utilizing surplus power from the Bonneville and Grand Coulee hydroelectric projects. When the need for the expansion of the industry in connection with the defense program became apparent, the original program was expanded to include other processes and to investigate the methods of producing magnesium oxide from low-grade magnesites and dolomites.

At the beginning of this work, a study of various magnesium processes indicated that the most promising field for research was electrothermic reduction of magnesium oxide by carbon. The original experimental program was drawn up to study and improve processes of this type.

After extensive small-scale experimental work on the various operations of reduction, shock-cooling and distillation, a continuous process was developed which is described as follows: Magnesite ore is concentrated by flotation to yield a product containing not less than 45 percent MgO and not more than 1.5 percent SiO_2. This is calcined in a rotary kiln to produce a calcine containing not less than 90 percent MgO.

The calcine is mixed in a rod mill with 23 percent low-ash carbon. The mixture is fed automatically into an arc furnace at a controlled rate and reacts to form magnesium vapor and carbon monoxide. These products issue at high velocity through an orifice into the shock-cooling flue, where they encounter an atomized spray of light fuel oil. Evaporation of a large part of the oil cools the furnace gas from 2,000 deg. C. to less than 200 deg. C, almost instantaneously.

The rate at which oil is supplied is so regulated that the unvaporized portion is just sufficient to form a fluid suspension of the metal condensate. This regulation is controlled automatically by the temperature of the cooled products. The solid products consist of magnesium metal, magnesium oxide, carbon, silicides and carbides of the ore impurities intermixed with liquid oil. The vapor phase is composed of oil vapor and carbon monoxide plus some hydrogen and methane resulting from the thermal dissociation of the oil.

The solid condensate and liquid oil are separated as a sludge from the oil vapor and gaseous products in a centrifugal separator of special design. The oil vapor subsequently is condensed in a water-cooled scrubber, and the lighter fractions are recovered in refrigerated coils. The exit gas contains about 50 percent CO, 30 percent hydrogen and 20 percent methane. These have a fuel value about equal to that of the dissociated oil.

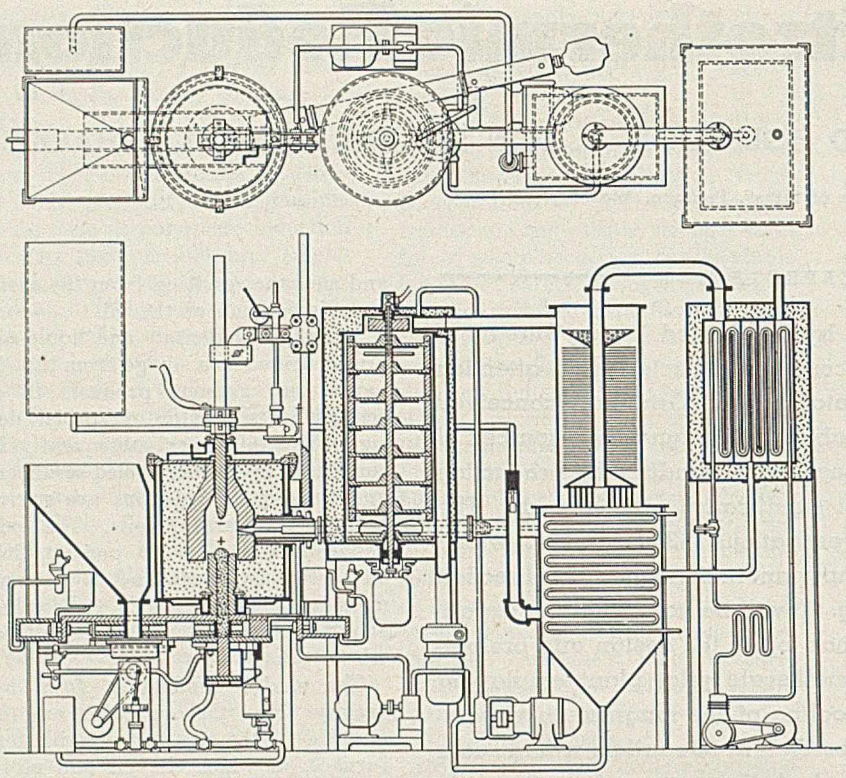
The sludge condensate flows by gravity from the separator and is pumped to the two-stage distillation furnace, in which the oil and magnesium are recovered separately by distillation. The oil thus recovered combined with the oil previously condensed in the scrubber is recirculated through the spray nozzle.

The oil-distillation unit includes a horizontal retort electrically heated to 500 deg. C. The sludge is recovered through this retort in pans attached to a pair of chains. The oil vapors are swept from the retorts to a water-cooled condenser by a current of hydrogen circulated through the gas-tight system. The small amount of hydrogen lost through leakage is replenished by cracking of the oil.

The removal of oil from the sludge leaves small, dry, porous cakes containing about 50 percent magnesium metal. These briquets drop out of the pans into a hopper from which they are fed into cages. The charged cages completely fill a horizontal, alloy-steel retort, heated by electric resistors to 1,000 deg. C. The magnesium metal evaporates from the briquets, and the vapor is carried by a current of hydrogen to a condenser, from which the molten metal is tapped.

Movement of the cages through the retorts and their return to the feed are accomplished by a ram and drag-chain mechanism, both of which operate outside the heated zone. The charging of briquets, discharging of residues, and all movements of the cages are accomplished automatically.

Although continuous and uninterrupted operation of the pilot plant



Plan view and sectional elevation of the magnesium reduction unit assembly

has not yet been realized, the results that have been obtained show that it is practicable to use oil or liquid hydrocarbons as shock-cooling medium. Oil has been found to be as effective as gas for shock-cooling magnesium vapor when atomized in a nozzle of proper design. At the same time it offers many advantages that make the equipment required smaller and less expensive and permits safer and simpler operation.

A satisfactory grade of oil for the purpose is light stove oil. Only 25 lb. of such oil has a cooling effect equal to approximately 1,000 cu.ft. of gas. The total volume of gas and oil vapor per pound of magnesium is about 150 cu.ft. at atmospheric pressure at a temperature of 180 deg. C. For shock-cooling with gas, the total volume of exit gases under the same conditions is more than ten times greater. This difference in volume of the gaseous product represents considerable difference in the size and cost of equipment for handling the gas and separating it from the condensates. Furthermore, since the condensate from the reduction furnace is protected from oxidation by the oil, the hazards and problems with handling a pyrophoric substance are, in large part, eliminated.

The following data represent an average for operation of a unit.

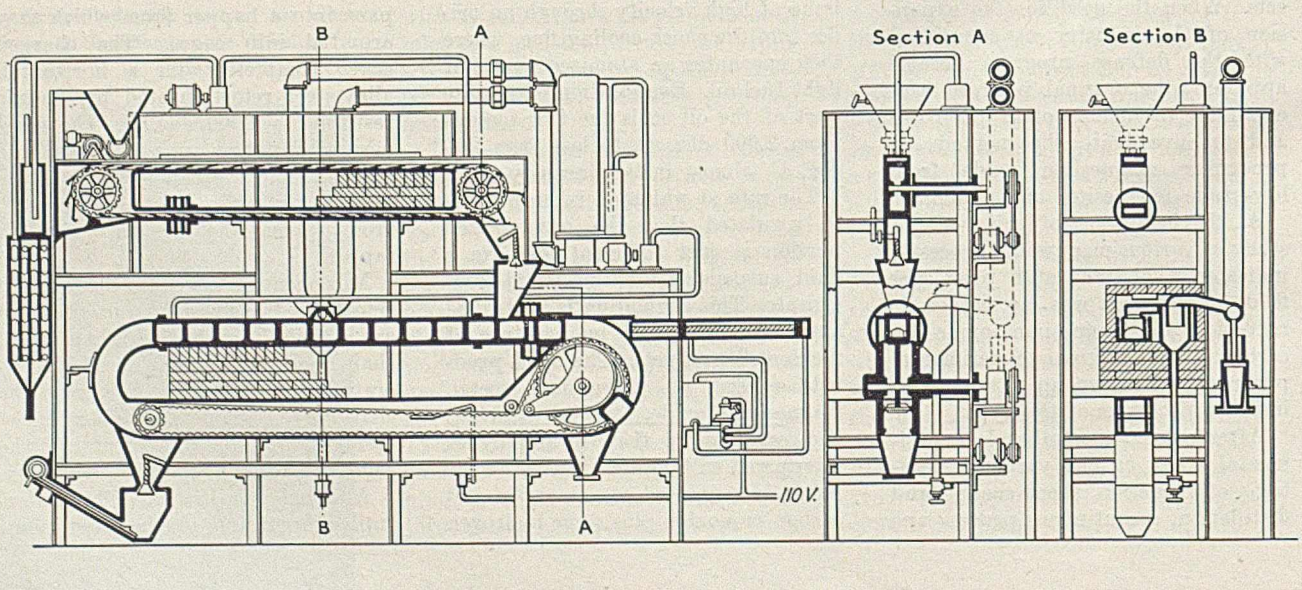
Operation Data for Reduction Unit

Capacity, lb. Mg per hr.	7.11
Conversion, percent	76.8
Power consumption, kwh. per lb. Mg	12.3
Oil consumption, lb. per lb. Mg	0.75
Electrode consumption, lb. per lb. Mg	0.18
MgO in condensate, lb. per lb. Mg	0.50
Carbon in condensate, lb. per lb. Mg	0.62
Byproduct gas (CO, H_2, CH_4), cu.ft. per lb. Mg	26.5

Development of the two-stage continuous distillation process has not yet progressed to a point where a full-sized commercial unit could be designed. Operations of this unit had to wait successful operation of the reduction unit so that development has been slower. The distillation operation involves a number of problems of design and heat transfer that become increasingly complex as the capacity of the unit increases, making it necessary to attempt only gradual development of successively larger units. From experience with the small distillation unit, it seems likely that a unit could be developed that would have a capacity of 100 lb. of metal per hr. with an energy input of 150-200 kw. Assuming a radiation loss of 10 percent, it is estimated that this unit would require 0.57 kwh. for the oil distillation and 1.16 kwh. for magnesium distillation, a total of 1.73 kwh. per lb. of metal produced.

Further work is being carried out to investigate a new type of distillation operation, which is expected to permit considerable increase in capacity.

Two-stage continuous distillation unit in which oil and magnesium are recovered separately



Managing New Product Development in Chemical Industry—I

JOHN C. COLLINS *Chemical Engineer, Carbide & Carbon Chemicals Corp., S. Charleston, W. Va.*

Chem. & Met. INTERPRETATION

Chemical industry has set an outstanding record in the number and quality of new products introduced within the last few decades. However, little has been written about the techniques used by chemical management in approaching and carrying out these developments. This phase of industrial expansion and competition will take on a new significance when peace finally comes and executives of those concerns that hope to survive and expand must continue their habits of planning well in advance of anticipated events.—*Editors.*

One general approach to new product development is, of course, to appropriate funds, hire scientists and then tell them to go to work to discover something of value to the company. This method has not been very successful because it lacks direction. To secure the best results, research and development must be steered, coordinated, and managed in a way consistent with other activities of the company.

However, new product development is only one phase of the research and development activities in a large chemical concern. Other related objectives include finding new uses for existing products, improving present products and processes, developing new processes, and fundamental research to advance scientific knowledge.

In the following sections new product development is discussed as a series of logical steps from the inception of ideas through the preliminary screening process, the research and development stages to the final transfer to full-scale operations. In each of these steps, both technical and economic factors are considered.

SOURCES OF IDEAS

First step in product development is to find good ideas for new products. At certain times management searches aggressively for a good idea to fulfill a specific need, but at all times it must make provision for a steady influx of ideas. New product suggestions come from many different sources and it is necessary to stimulate and develop these at all times. Sources that have been found important by executives in the chemical industry are listed according to their point of origin.

Research Department—Since research men spend much of their time working on new products it is natural that they furnish many ideas for other new chemicals. Their ideas usually appear in the form of suggested chemical compounds and possible ways of making them. In many companies, this source is stimulated by conferences of entire research and development staffs several times a year to provide an opportunity to compare notes and discuss technical problems. Frequently new chemical compounds are discovered by accident or through "leads" uncovered during the investigation of some other problem, thus turning out to be by-products of other research projects. As one executive put it, "New chemicals often show up as branches on the tree of another research project."

Sales Department—Different companies in the chemical industry have had different experiences with salesmen as originators of ideas. Comments range from "No good ideas for new products come from salesmen" to "Salesmen are an important source of ideas for new chemicals." The value of salesmen for this purpose seems to depend on their technical training, the nature of their work, (whether primarily selling or sales engineering), and whether they are expected to devote some of their time to thinking up ideas for new products, new markets and new uses.

Market development and sales service men who do experimental selling and customer-contacting seem to be very valuable in bringing in new ideas based on their experience with customers' problems and their understanding of chemical technology.

Customers—Many companies are trying to get more and more ideas for new products from their customers. These may be funneled through salesmen and market development men or they may be brought in by the customers themselves if they feel that the chemical concern can actually do something about the suggestion. There is one difference in approach to new products which is illustrated by the ideas from research men and those from the sales department and customers. Suggestions from the former are usually based on specific chemical compounds, and the succeeding development consists of developing a process and finding uses for the product. On the other hand, ideas from customers and salesmen are usually based on industrial needs and desires, and the development consists in finding products to meet these needs. The chemical industry has often been criticized for not using the "customer need" approach more frequently. However, there is evidence that most chemical companies use both approaches and try to strike a balance between the two.

Inventors—Almost all of the executives interviewed agreed that inventors are a poor source of new

For several years the Department of Business and Engineering Administration at Massachusetts Institute of Technology has been studying the problem of management of new product research and development. The present study, made in partial fulfillment of the requirements for the degree of Master of Science, is one of several to be made in that field. Material for this investigation was gathered in a series of personal interviews with executives in several representative firms in the industry. The author, who is also a graduate in chemical engineering from the University of Washington, will conclude the series next month by discussing management of large scale development, transfer to commercial production and management problems in general.—*Editors.*

product ideas. Nevertheless, provision was made in every company to scrutinize suggestions from inventors in order to avoid overlooking a good opportunity. One executive stated, "Most of the ideas of inventors are old ones in a new form. In addition, most inventors do not understand or realize the capabilities of the company, such as its usual raw materials, methods of manufacture, product lines, etc."

Executives—Ideas for new products may come from executives if their training, experience, and interests lie close to product development activities.

Other Chemical Companies—Ideas are obtained from other chemical companies directly by transfer or sale, or indirectly by making an analysis of competitors' products with the object of finding out what weaknesses or gaps are apparent. Other minor sources of ideas include the technical literature, fellowships in universities, and charts of derivatives of present products.

SCREENING OF IDEAS

Next step in the development process consists of selecting certain of the more promising ideas for intensive research and development. This necessitates the screening process, in which various aspects of each suggestion are considered before it is turned over to the research and development workers. Many proposed projects are rejected in this stage of examination. Usually several executives participate in the screening process, as it is necessary to consider every element that affects the chances of ultimate success of the new product. The chief research executive is usually the most important person in the selection process since he passes judgment on technical aspects.

In some companies there is a separate department, often called the development division, which considers the economic factors. In addition, most companies have research committees composed of executives from each of the major departments of the concern. These either control the selection of research projects or act in an advisory capacity to the chief research executive. Factors usually considered in preliminary screening are outlined in the following paragraphs.

Company Policy—This defines the field of activity and interest of the particular company and indicates which general classes of new products should be considered. Most chemical companies prefer new products that will utilize their own "know-how" and peculiar abilities, that can be sold to the same type of customers as those already served, and that are chemically related to present products.

Chemical Feasibility—This factor is always studied in the early stage by discussions and "paper work" and frequently by conducting a few experiments in the laboratory. One director of research has been authorized to spend without special permission up to $500 for preliminary research on any one idea.

Engineering Feasibility—Ordinarily, engineering questions are not considered in great detail at this stage unless it seems likely that they will later offer difficulties. The availability of suitable materials of construction, design of unusual equipment and containers, and similar engineering problems are investigated in a preliminary way by chemical engineers to make sure that engineering difficulties will not "kill" the project at a later stage.

Hazards of Manufacture and Use—If possible, these elements are studied during the preliminary screening stage. Usually, however, it is not possible to completely evaluate such hazards until quantities of the new product have been made in the laboratory.

Cost of Manufacture—This factor, extremely important to any company, is studied as completely as possible during preliminary screening. Usually only rough guesses can be made, based on raw material costs, theoretical yields, and average allowances for other elements of cost. The purpose of cost estimates at this stage is to avoid undertaking research on entirely impractical ideas.

Cost of Research and Development—Executives agree that it is almost impossible to forecast accurately the cost of developing a new product, but most of them do make preliminary estimates based on their previous experience.

Return on Investment—A preliminary estimate is usually made of the expected return on the investment in research and plant facilities, since this factor is of most interest to the top management. This return is based on estimates of markets, costs, and fixed capital. Like them, it is an approximation which may not be very accurate but which is better than no estimate at all.

Competition—One of the duties of those selecting new product ideas is to consider the status of competitors in the field in which the new product will enter. One executive said that he tried to estimate competitors' costs and to forecast their actions when the new product was released.

Size of Market—It is difficult to estimate in this preliminary stage the quantities of the new product which could be sold, but an attempt is often made to do so. However, practice in the industry seems to vary widely. Some companies wait until research has been completed before estimating the potential market while others make market surveys as the first step in screening ideas. The purpose of preliminary market surveys is to determine if the potential demand is large enough to justify development of the product.

Raw Materials—It was indicated by most executives that raw materials are not studied to any great extent at this stage. It is to be expected, however, that the present material scarcities will make it imperative to investigate this aspect before extensive development is undertaken.

Patents—A patent attorney familiar with the field of the proposed new product usually indicates the general patent situation and the difficulties that might be encountered.

In the screening process the object is to investigate in a preliminary way all factors which must be studied more thoroughly later as well as to locate the strategic factors and to subject them to careful scrutiny. One executive stated, "Perhaps the first steps in new product development may be summarized by stating that the weakest links are sought by high-spot studies and that these are followed to the 'bitter' end. Eventually, of course, all pertinent factors must be studied in considerable detail if the recommendation is made to go ahead. On the other hand, if one of the 'weak links' in the chain proves to be unavoidable and disastrous, many other factors are never studied."

RESEARCH STAGE

The core of this stage is the chemical laboratory research carried out by chemists and physicists to explore ways of making the new product on a laboratory scale. The techniques used by research scientists need no explanation. It is interesting, however, to take a bird's-eye view of the entire technical development process, of which laboratory research is just one part.

Executives were asked whether a new chemical product always went through the five steps of small-scale and large-scale laboratory work, pilot plant, semi-commercial plant, and finally full-scale plant production. Answers ranged from, "A new product should always go through all of these stages, unless the company wishes to gamble," to "We try as far as possible to eliminate one or more of these steps, since we feel that a smart research organization can use only those steps absolutely necessary for each new product." The characteristics of the particular chemical being studied are undoubtedly the controlling factors, but there is still some leeway to exercise judgment in deciding whether to omit one or more steps. The reason for such an elimination is to save time so that the product can be released to the market at an earlier date. However, some risk is taken inasmuch as difficulties may later be encountered which could have been found and eliminated on smaller scale work.

Before research activities are started, the director of research usually plans the general line of attack so that the experiments are directed toward the proper goals. One type of planning consists of making up a list of specifications to which the final product should conform. In one company this list is called a directive and includes requirements which must be fulfilled, as well as recommendations on certain properties desirable but not absolutely essential. This aids the manager in deciding when a new product should be transferred from the laboratory into the pilot plant.

PROGRESS REPORTS

Control over research activities is exercised in many ways. In most companies, research groups are required to submit progress reports once a month in addition to the quarterly and yearly reports. These indicate to the research director what progress is being made on each project and helps him in directing the activities.

Financial control is usually exercised through appropriations in the company budget for research and development expenses. There is evidence that in many companies these budgeted amounts are very flexible and do not constitute a tight restraint on research activities. While the appropriation may be broken up into assigned amounts for each project, these amounts seem to be milestones by which progress is measured rather than stopping places. In most cases a research project is not terminated when the assigned allocation is spent.

Patent protection for discoveries made in research is procured by staffs of patent attorneys who work closely with the research scientists. Some companies have staffs of patent attorneys which specialize by groups of chemical products so that they can understand better the nature and importance of discoveries made in these fields.

ECONOMIC FACTORS

Along with laboratory research, investigations are usually made of several economic factors, including manufacturing costs, markets, packaging and shipping requirements. In almost every company, estimates of the cost of manufacture are made frequently during the process of research and development, each succeeding estimate becoming more and more accurate. These are sometimes made by the research workers themselves, and sometimes by a development staff which specializes in studying economic factors.

Market studies are often made completely in the preliminary screening stage but sometimes not until the product is in the pilot plant. Most often they are made while the product is in the laboratory. Some companies make complete surveys for each new product, while others estimate markets primarily on the basis of the demand for samples of the new product. In some concerns there are "market research" staffs which specialize in making the surveys, including statistical studies of production and consumption data and field interviews with potential customers. In other companies reliance is placed on the judgment of the executives as to the size of the market.

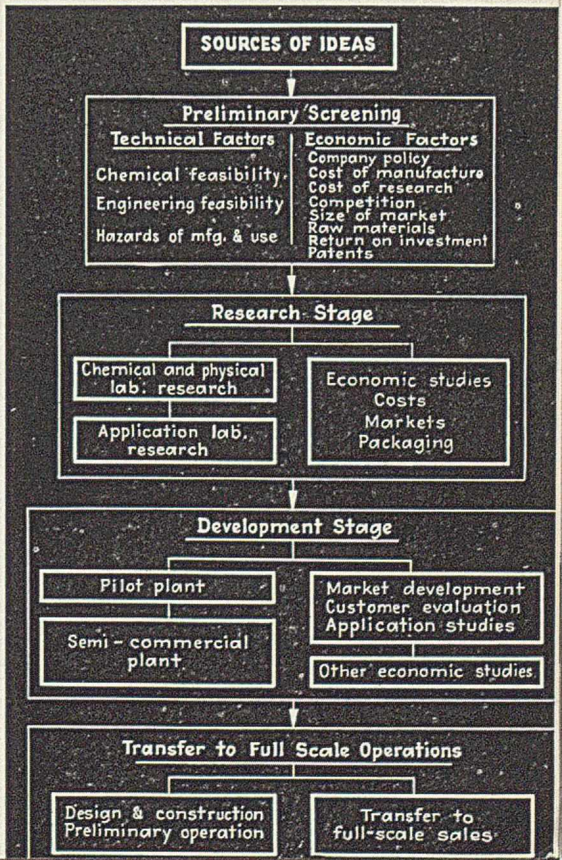
Packaging and shipping requirements usually require study by research workers, engineers, the sales department, and the transportation department. When standard containers can be used, these problems do not require much attention. However, in other cases, special containers must be designed and constructed.

There is one distinction between synthesizing a new chemical product in the laboratory and evaluating its utility, and this is often made the basis for a separation between the research and the applications laboratories. The latter are concerned primarily with the determination of properties and uses of the new products developed by the research laboratories. An application study is made either simultaneously with the research work or after a substantial portion of research has been completed. The report of the applications laboratory furnishes the executives with a valuable evaluation of the new chemical as developed in the laboratory.

Applications laboratories in many companies are divided into groups dealing with allied products for customer industries. Examples include such divisions as textile chemical laboratories, lacquer laboratories, and rubber chemical laboratories. In some large concerns where there are several operating divisions, an applications laboratory is maintained by each division, while pure research work is centralized in one main laboratory. The applications division also frequently does customer service work.

At times the application study is carried further by testing small samples of the product in customers' plants. Most companies defer such testing until large quantities are available from pilot plant operations, but in some cases tests are made during both research and pilot plant stages. The laboratory product of one company is tested in a limited way in customer plants by a research chemist from the producing company, while the pilot plant product is tested thoroughly in customer plants by special "contact" men. Large scale development and testing of new products in customer plants will be discussed fully in a later issue.

Diagram showing the normal phases of new product development in chemical industry. Technical and economic factors are investigated simultaneously



Special Slide Rules Can Facilitate Many Engineering Calculations

G. T. AUSTIN *Purdue University, West Lafayette, Ind.*

Chem. & Met. INTERPRETATION

Special single-purpose slide rules designed to solve chemical engineering equations are valuable when repetitive computations must be made, especially by mathematically unskilled persons. Design and construction of such rules is not difficult. The author describes three types of equations which can be set up on rules, showing in detail how each type is handled. Although mentioning that suitable blanks for special rules can be purchased, he shows how blanks can easily be constructed from cardboard, wood or other materials.—*Editors.*

Ordinary slide rules have long been important mathematical tools of the chemical engineer. Special rules, limited in their application to the solution of a single equation, have been utilized to considerable advantage in other fields of engineering for some time, articles on their construction having appeared in the literature as early as 1904. It is rather surprising, therefore, that their use has not been more extensive in chemical engineering, especially since the equations used in heat transfer and fluid flow are quite well adapted to such rules.

Nomographs are frequently encountered in chemical engineering work. Since a special slide rule is merely a modified type of nomograph, much of the material now used in nomographic form could be handled on slide rules with equal or better accuracy and a considerable increase in handling convenience. Slide rules are superior to nomograms in being more portable and less subject to error in reading, while they require no auxiliary equipment.

The type of slide rule described in this paper is not intended for manufacture and sale, but for construction and use within an individual plant or office. Where fairly complicated computations must be repeated frequently, or where computation must be placed in the hands of mathematically unskilled persons, special slide rules offer an almost ideal method of solution. An excellent example of the simplicity of operation achieved by using a special slide rule is shown in Fig. 2. This computation ordinarily requires the use of a log slide rule and, when Reynold's number exceeds 20,000, the use of logarithms. On the special slide rule shown, all powers are automatically taken into account and only values of the variable need be set. No conversion factors are required and the actual values of the inside pipe diameters need not be sought in a table.

SLIDE RULE PRINCIPLES

Principles underlying the construction of slide rules of all types have been known for some time and are discussed in several well written articles and texts. These works were, however, not written by or for chemical engineers and seem largely to have escaped the notice of most students in this field. In general, methods and terminology used in this article are essentially those of Hoelscher, Arnold and Pierce[3], although material has been used from other sources.

The basic principle involved in the construction of slide rules is the addition of lengths proportional to the values of functions; the addition of the lengths being equivalent to the addition of the functions themselves. This principle is fully discussed in several of the references[3,5] and needs no discussion here. When the functions used are logarithmic, addition of the functions is equivalent to multiplication of the variables.

Major problems involved in laying out special slide rules are to find (1) the type of rule necessary, (2) the direction in which the scales must run and (3) the method of properly subdividing the scales.

Type of Rule—Many types of combinations of fixed and sliding scales are possible, but three fundamental types are satisfactory for most problems: (1) the single slide, (2) the double slide and (3) the middle support. These three types are illustrated in Figs. 1, 2 and 3, and 4 respectively. Each type is suitable for different types of equations.

Let $f(x)$ be defined as an expression containing only the variable x; for example x, $\frac{1}{4}\log x$,

$$\frac{e^x\text{-}\log x + \cos^3 x}{\tanh 3/x},$$

$x^{2.13}$, etc. This is the customary algebraic definition of $f(x)$.

Using this definition of $f(x)$, the following types of equations may be solved by rules of the three types previously mentioned as shown below:

Form of Rule	Type of Equation	
Single Slide	$f(x) + f(y) + f(z) + f(\theta) = 0$	(1)
Double Slide	$f(x) + f(y) + f(z) + f(\theta) + f(p) + f(q) = 0$	(2)
Middle Support	$f(x) + f(y) + f(z) = f(k)$	(3a)
	$f(\theta) + f(p) + f(q) = f'(k)$	(3b)

Examples of each type of rule are given in this paper showing a typical problem solved by each rule. Any one term in the above equations may be replaced by zero, in which case an index point replaces a scale. The addition of a constant term does not affect the status of the equation. The use of an index point is illustrated in Fig. 4. Considerable ingenuity is sometimes necessary to get given equations into one of the foregoing type forms (1), (2) or (3).

Direction of Scales—When the type of rule required has been determined, the direction in which the values of the function will increase (i.e., whether values increase to the right or the left) must be determined. This is a comparatively simple matter if the following rules are observed:

1. Write the equation with all terms to the left of the equals sign.
2. Write the terms of the equation in the order in which they are to appear on the slide rule in a vertical row, reading from top to bottom of the rule.
3. Prefix alternate plus and minus signs to the right and left of the functions listed.
4. Draw arrows in the direction of the sign prefixing the term, as written under Rule (1).

The arrow indicates the direction of increasing values of the function. It should be noted that the order of increasing values of the variable may be reversed from the order of increasing values of the function (e.g., when $f(x) = 1/x$). Examples of the application of these principles are shown below under the individual equations for which slide rules are illustrated.

Length of Scales—The length of scales is determined by the range of values of the variables used in constructing the scales. Since lengths of the scales are proportional to the values of the functions, the range of values is multiplied by a number m, called the functional modulus, to obtain the scale length. This functional modulus must be the same for all scales on the rule, and its value is determined by the function which has the greatest proportional range of values. Stated mathematically:

$$L_x = m\,[F(x) - \phi(x)] \quad (4)$$

where L_x = length of scale for $f(x)$, in inches; m = functional modulus, inches of length per unit of the function; $F(x)$ = largest value of $f(x)$; and $\phi(x)$ = smallest value of $f(x)$.

LAYING OUT SCALES

In laying out logarithmic scales, it is convenient to have at hand a series of logarithmic cycles of various lengths. These may be constructed as shown by Davis and Genereaux[7], or by means of an ordinary slide rule and proportional dividers if these are available. A chart as prepared by Arnold[1] is exceptionally convenient for this purpose.

The above principles of construction were utilized in the construction of the rules illustrated in Figs. 1 to 4. None of the rules illustrated requires a slider. The operation in each case is to match a variable with a variable until the final answer is read opposite the last variable employed. As an example, in Fig. 2, one problem solved when the rule is set as shown is: $k = 0.14$, $D = 1.5$, $\mu = 25$, $c = 1.5$, Re = 10,000, giving $h = 500$.

The means of constructing the slide rules illustrated herein are discussed below in some detail in order to afford greater clarity to the method outlined above.

Example I—Rule with single slide (Fig. 1). McAdams[8] gives the equation $h = (154 + 1.6t)\ V^{0.8}D^{-0.2}$ for finding the film coefficient of heat transfer for water flowing in turbulent flow inside horizontal pipes. Here h = coefficient of heat transfer, B.t.u. per hr., sq. ft. and deg. F.; V = velocity, ft. per sec., based on a density of 62.3 lb. per cu. ft.; D = inside diameter of pipe, inches; and t = temperature of water, degrees F. If we arrange this equation in logarithmic form, we obtain the following:

$$\log h + 0.2 \log D - \log (154 + 1.6t) - 0.8 \log V = 0 \quad (5)$$

This equation is of the form given in Equation (1), so it may be represented by a single slide rule.

Let us suppose that we wish to use the rule for problems involving the following limits: $6<D<1$ in., $200<t<40$ deg. F., $5<V<0.5$ ft. per sec., and $1{,}000<h<100$ B.t.u. per hr., sq. ft. and deg. F.

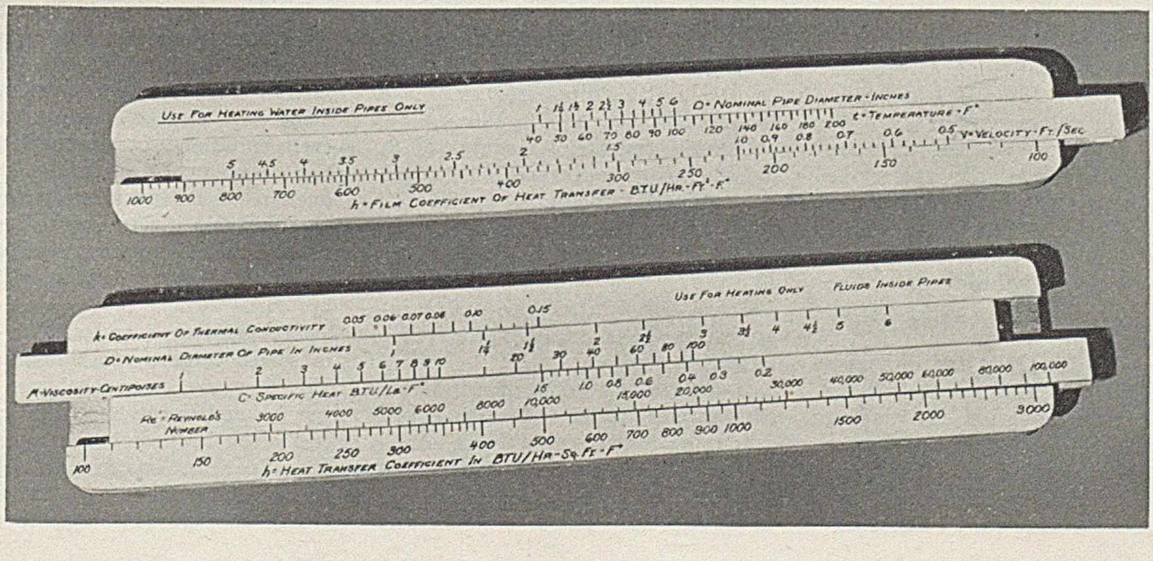
Applying Equation (4) to each of the variables in turn, we obtain: $L_h = m(\log 1{,}000 - \log 100) = m = 13.0$ in.; $L_D = m(0.2 \log 6.025 - 0.2 \log 1.049) = 0.152\ m = 2.0$ in.; $L_V = m(0.8 \log 5 - 0.8 \log 0.5) = 0.8\ m = 10.4$ in.; and $L_t = m[\log(154 + 1.6 \times 200) - \log (154 + 1.6 \times 40)] = 0.377m = 4.4$ in.

If a blank slide rule 14 in. long is to be used and we wish to allow the longest scale to run 13 in., we may by inspection evaluate $m = 13$, since the longest scale, from the above equations is m in. long. This value of m gives the scale lengths given on the right of the above equations.

To obtain the direction of the

Fig. 1—Single-slide rule for solution of water heating problems

Fig. 2—Double-slide rule solves Dittus-Boelter equation for liquid heating



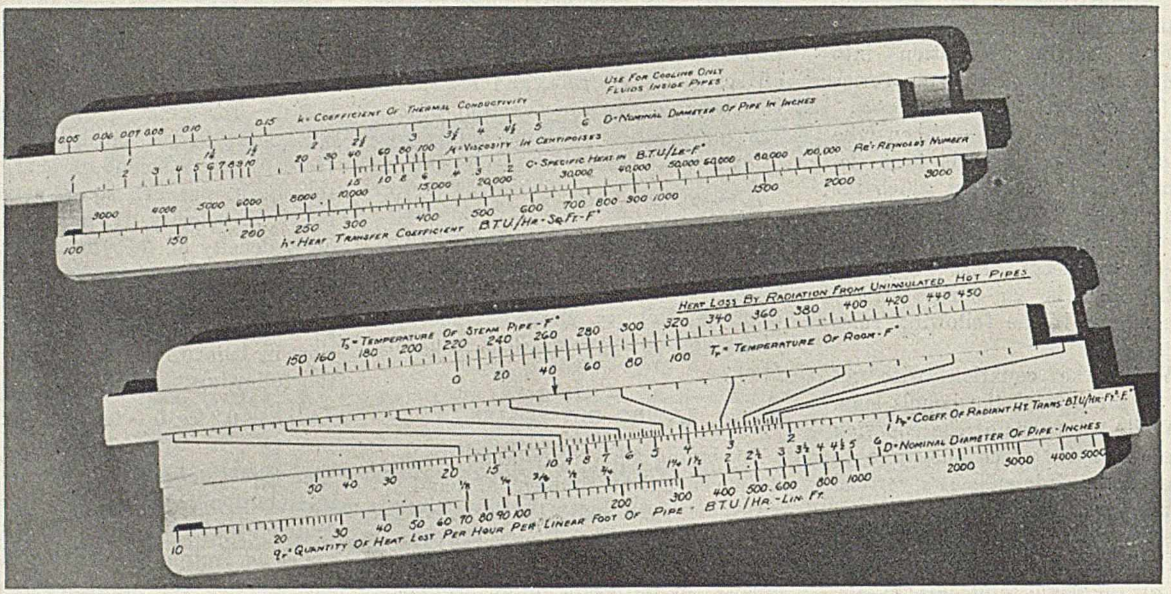


Fig. 3—Double-slide rule similar to Fig. 2, for liquid cooling problems

Fig. 4—Center-support double-slide rule for radiation losses from pipes

scales, we apply to Equation (5) the rules given earlier, and obtain:

(a) − D + → or (b) ← + D −
  + t − →   ← − t +
← − V +   + V − →
← + h −   − h + →

Using Set (a), then, scales for V and h must increase to the left, those of D and t to the right.

The scales for h and t may now be graduated by using a logarithmic cycle 13 in. long. Values of $(154 + 1.6\,t)$ should be laid out, since $f(t) = 154 + 1.6\,t$, but each graduation should be marked with the corresponding value of t, not $154 + 1.6\,t$, this makes the rule direct reading. Values of D may be measured with a log cycle $0.2 \times 13 = 2.6$ in. long. If values plotted are those of actual inside diameter of the pipe as determined from tables, but the values are labeled as the nominal diameter of the pipe, the rule will be direct reading for standard pipe sizes. The V scale is laid out using a logarithmic cycle $0.8 \times 13 = 10.4$ in. long.

One set of values must now be substituted into the original equation and a solution obtained. After the scales are graduated, they are glued to the slide rule blank in such a manner that the values substituted above are satisfied throughout. The rule will then satisfactorily solve all problems within its range.

Example II—Rule with double slide (Fig. 2). This rule solves the Dittus-Boelter equation for finding the film coefficient of heat transfer for liquids being heated inside horizontal pipes. This indicates the use of the double slide rule. The equation involved is $hD/k = 0.0225\,(Re)^{0.8}\,(c\mu/k)^{0.4}$ where h = film coefficient of heat transfer, B.t.u. per hr., sq. ft. and deg. F.; D = inside diameter of pipe, ft.; k = thermal conductivity, B.t.u. per hr., sq. ft. and deg. F. per ft.; μ = viscosity in English units (centipoises × 2.42); c = specific heat, B.t.u. per lb. and deg. F.; and Re = Reynolds number, dimensionless.

To adapt this equation to slide rule use, it is modified as completely as possible to $1 = (0.0225\,Re^{0.8}c^{0.4}\mu^{0.4}k^{0.6})/hD$ which, written in logarithmic form becomes:

$$\log 0.0225 + 0.6 \log k - \log D + 0.4 \log \mu + 0.4 \log c + 0.8 \log Re - \log h = 0 \qquad (6)$$

This last equation is in the form of Equation (2), so a double slide rule is indicated.

Limits chosen for the variables are: $0.15 > k > 0.05$, $242 > \mu > 2.42$, $100{,}000 > Re > 3{,}000$, $0.5055 > D > 0.0874$ (Std. pipe sizes), $1.5 > c > 0.2$ and $3{,}000 > h > 100$.

Using a functional modulus of 9, obtained by the inspection method shown in Example I, $L_k = 2.6$ in., $L_D = 6.9$ in., $L\mu = 7.2$ in., $L_c = 3.2$ in., $L_{Re} = 11.0$ in. and $L_h = 13.3$ in.

Scales for k, D, μ, Re and h increase to the right, that for c increases to the left.

By calculating values of μ in terms of centipoises, the scale for μ was graduated to read directly in centipoises by a method analogous to that employed in laying out the D scale in Example I. The D scale in this case was graduated to read directly in inches nominal diameter, although laid out as feet actual diameter by a similar method.

The scales were located on the rule with reference to one another by calculating out one specific case as was done in the previous example.

The rule shown in Fig. 3 differs from the one of Fig. 2 only in the exponent of the Pradtl number in the equation on which it is based. In the case of Fig. 3, this exponent is 0.3.

Example III—Rule with middle support (Fig. 4). This rule illustrates the use of an index line and uniform scales. The purpose of the middle fixed scale is to accomplish a transfer of the value of the function which it represents from one side of the rule to the other. Thus it is, in effect, two related single slide rules on a fixed base. The middle-support rule can solve two equations simultaneously, or may be used to solve a single equation of more variables than can be handled conveniently on other types by the introduction of an auxiliary variable. Introduction of an auxiliary variable is used in this illustration. The scale for this auxiliary variable is always graduated, but is not usually calibrated.

The equation $q_r = h_r A\,(T_s - T_r)$ is solved by the rule illustrated in Fig. 4, where q_r = heat lost, B.t.u. per hr. and linear ft. of pipe; h_r = coefficient of radiant heat transfer, B.t.u. per hr., sq. ft. and deg. F.; A = external area, sq. ft. per ft. length of pipe; T_s = surface temperature of pipe, deg. F.; and T_r = temperature of the room, deg. F. The auxiliary variable k is introduced to make the equation suitable for slide rule use and the equation then becomes $q_r/h_rA = T_s - T_r = k$. Or,

$$\log q_r - \log h_r - \log A = \log k \qquad (7a)$$
$$T_s - T_r = k \qquad (7b)$$

Equations (7*a*) and (7*b*) are of the form of Equation (3), which shows that the original equation can be represented by a middle support rule.

Considering (7*a*) and (7*b*) separately, individual single slide rules are now plotted on the lower and upper portion of the rule. The scales for k on both the lower and upper parts of the rule should be made to increase in the same direction.

The same functional moduli need not be used on both the upper and lower halves of the rule. As shown, a modulus of 1/30 is used for the upper half of the rule and a modulus of 5 for the lower half. The index point is located by means of a calculation so that it reads correct values on the upper k scale when set on values of T_s and T_r.

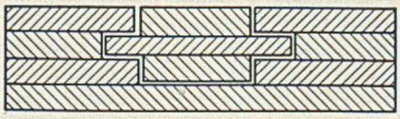
Lines are now drawn connecting equal values of k on the upper and lower k scales.

The operation of the rule is as follows: Set values of T_r opposite the corresponding values of T_s. Set h_r opposite the value on the lower k scale indicated by the index point on the upper k scale. (The lines connecting the two k scales are to assist in this step.) Opposite the value of D read the corresponding value of q_r. In the rule shown in Fig. 4, the variable A does not appear but, since it is a function of D, the value of D is used, thus eliminating the necessity of calculating A for any given D.

The above examples serve to show the general applicability of special slide rules to chemical engineering problems. The method of construction is simple and direct. Any points in the above discussion that are not immediately clear may be most readily cleared up by performing the operations necessary to construct a simple rule. More elaborate treatment of some of the minor points may be obtained in some of the treatises on the subject[1,3]. A little practice should enable anyone with engineering training to construct rules for many of the more common formulas whose solutions are repeatedly required. The author has found the rules illustrated very convenient in rapidly checking the work of students, and in certain simple design problems. Such a rule need be used only a few times to repay fully the small amount of labor necessary to construct it. In times such as the present when calculations must frequently be put in the hands of young or unskilled workers, the freedom from error accompanying the use of these simple rules in such problems as acid mixing should prove most definitely their value.

Prepared slide rule blanks on which to paste the scales laid out according to the above directions are available[8], but suitable blanks may be made from cardboard, hard rubber or other material at hand. Cardboard, sheet resin or wood work out well when glued as shown in Fig. 5.

Fig. 5—Cross section suggesting method of rule construction



The author wishes to express his gratitude to Professors J. N. Arnold and C. L. Lovell of Purdue University for their interest and suggestions during the preparation of this manuscript.

Bibliography

1. Arnold, J. N., "Special Slide Rules," Engineering Bulletin No. 32, Purdue University, West Lafayette, Ind.; 1933 (Out of Print).
2. Hoelscher, Arnold and Pierce, "Graphic Aids in Engineering Computations," The Garrard Press, Champaign, Ill., 1939.
3. Lipka, J., "Graphical and Mechanical Computation," John Wiley and Sons, New York, 1918.
4. Mackey, C. O., "Graphical Solutions," John Wiley and Sons, New York, 1936.
5. Mavis, C. E., "The Construction of Nomographic Charts," The International Textbook Co., 1939.
6. McAdams, W. H., "Heat Transmission," The McGraw-Hill Book Co., New York, 1933.
7. Perry, J. H., "Chemical Engineers Handbook," The McGraw-Hill Book Co., New York, Second Edition, p. 257, 1941.
8. Roemer, L. H., 5712 Glengate Lane, Pleasant Ridge, Cincinnati, Ohio.

CHRONIC POISONING

(*Continued from page 81*)

We have, therefore, in regard to chronic poisoning hazards the following difficulties:

(1) Hazards are difficult to detect except by chemical or physical means.
(2) Effects of the poisoning are spread out over a long period of time and the results not noticed until the condition is far advanced.
(3) There is a very great difference in susceptibility, so that experience with an exposure over a long period of time is no indication that a new man might not die after a very short exposure to the same material.

The control of hazards of this chronic type can generally be accomplished in the following manner:

(1) Existence and seriousness of the hazard can be determined by chemical or physical tests. When the amount of a given material in the air and the number of hours per day that men are exposed to this material are known, it is then possible to state whether or not the danger of chronic poisoning exists.
(2) Next step is the substitution whenever possible of a non-hazardous material for the poisonous one.
(3) Exposure should be limited to as few operators as possible.
(4) Operations should be isolated as far as possible to protect employees not actually working on the job.
(5) Exposure can be minimized by rotating employees on the hazardous job.
(6) Men can be protected by use of ventilation and personal safety equipment, such as respirators and gas masks.

In regard to ventilation, it is important to prevent the fumes or dusts from ever getting into the air. One way toward accomplishing this is to ventilate by means of local exhaust hoods which remove the harmful material at the point of generation. This is much more economical than attempting to ventilate large working areas.

EXPERT ADVICE

When problems of chronic poisoning arise, it is very desirable to contact authorities who have knowledge regarding these hazards. The State Department of Industrial Hygiene, or in some states the State Labor Department, the National Safety Council or representatives of insurance companies all have considerable information regarding toxic limits and the control of toxic hazards. These agencies are always glad to cooperate in any way toward furnishing information or making studies. Such information and services are available without charge to practically any industrial plant.

It is hoped that this introductory article points out in a general way the problems encountered in industrial poisoning and hazards. Special problems of various chemicals or processes will be discussed in future installments to appear in this magazine during the next three months.

Operating Variables Charted by Electrical Recorders

REGINALD TRAUTSCHOLD *Consulting Engineer, Passaic, N. J.*

Chem. & Met. INTERPRETATION

Records of current load or voltage on electrical equipment serving process applications often supply reliable information on the progress of an operation or reaction, on down time or faulty functioning of equipment which cannot be recorded as simply or conveniently by other means. The author has studied several such applications for standard electrical recorders and has found that excellent, money saving results can be achieved in this simple fashion, for example, in the case of evaporators, crystallizers, sintering machines and conveyors.—*Editors.*

MEASURING operating variables electrically is in many instances a most effective and decidedly inexpensive way of ascertaining critical controlling conditions, in industrial manufacturing and processing undertakings. A few quite typical cases will serve to demonstrate this fact—just how important a role standard recording ammeters and voltmeters play nowadays in keeping down operating expenses and in supplying that indispensable guidance essential for close operating control in commercial production activities.

Sugar—At The Amalgamated Sugar Co. refinery, Nyssa, Oregon, standard Bristol recording ammeters are inserted in the circuits of the motors driving crystallizers and the instrument postings supply the information needed in controlling the saturation of the fillmass. The fillmass in the crystallizers cools and becomes more highly saturated as the process advances, causing the load on the motor to rise and the amperage consumption to increase. Consequently, the graphs traced by the recording instruments, of which Fig. 1 is an example, give irrefutable evidence of the working quality of the fillmass and when the process should be stopped. The measure is, quite obviously, one of attainment rather than of the influencing conditions—temperatures, machine speed and charge proportions—that govern the operation of the crystallizer, so the single measure supplies the quality gage by which the best influencing conditions are empirically established.

Pyrites—A somewhat similar recording ammeter application at the plant of The Pyrites Co., Inc., Wilmington, Del., serves the exhauster motor of a sintering machine and proves a highly effective and dependable detector of operating defects. The graph charted by the instrument placed in the fan motor circuit (Figs. 2*a* and 2*b*) provides a continuous record of the load on the exhauster and of the condition of the sintering bed —furnishing conclusive proof of the efficiency with which the sintering process of ore reduction is consummated.

DETECTING TROUBLE

The general characteristics of these load graphs, their form, likewise bring to light machine difficulties and defects that impose waste burdens and unduly elevate operating expenses. In the chart of Fig. 2*a* the load graph, while fairly symmetrical concentrically (and hence indicative of uniformity in average, or mean, power demand) is decidedly "saw-toothed" in outline. Pronounced peaks and valleys appear at substantially regular intervals. These variances in current requirements are evidences of machine defects, which in this particular case were found to be occasioned by bad grate bars and wearing strips. A correction of these faults was made and the load graph at once took the form shown on the second of the charts, Fig. 2*b*.

All fluctuations in power consumption were not eliminated, it is true, but the swing was reduced from one of substantially 10 per cent plus or minus to one of not more than a fifth as much, plus or minus. This 80 per cent improvement brings about in effect a like or even greater reduction in the wear and tear on the drive motor. Commenting on this gain, The Pyrites Co. stated: "Anything that gives us more uniform operation increases the net return for the same fixed expenditure."

Pulp—Quite a number of similar standard recording ammeters are employed by one of the large pulp and paper mills where they are used for recording the load on disk evaporator motors. In the words of the chief chemist of this organization: "By recording the load on these motors we have a good indication of the strength of the liquor in the evaporators as well as a good record of the mechanical condition of the evaporators. We find that this record is very helpful to the operators as well as a good protection for the motors."

Flour—Greater uniformity of product with less operating expense is also reported by the Western Milling Co. of Pendleton, Oregon. A recording ammeter maintains a continuous graph of the load carried by the 60-hp. motor on the head of the establishment's milling unit. This posted record serves as the guide by which the operators keep their mill adjustments at uniform extraction settings. Necessary control of the flour's moisture content is also reliably indicated by the postings of the recorder, for as the moisture content rises so also does the power consumption.

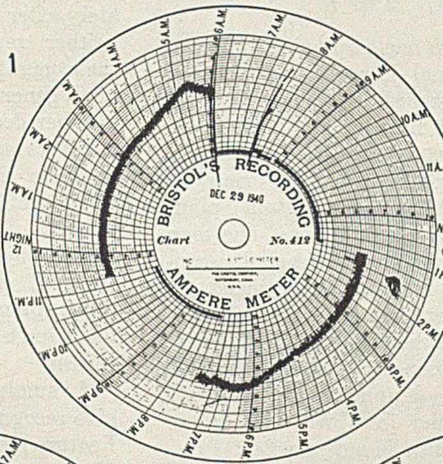
Coal Washing—At the washery of the Raymond City Coal & Transportation Corp., Cincinnati, the load on a flight conveyor drive is measured and posted by a recording ammeter, which provides a definite check on the washer service, including the duration of and accurate timing of washer operation. The charted graphs show the amounts of lost time and, consequently, have been responsible for corrections in details of plant operation. The charts have also accurately established the various capacities of the plant.

A chart of this recorder is, in fact, quite an illuminating record. Not only is the load on the washer's conveyor posted continuously, posted as and exactly when it occurs, but when both the conveyor and washer are in service the graph traced is recorded on the outer ring as a heavy inked line, as in Fig. 4. When the conveyor is running but not the washer, the graph traced on the inner ring is heavily inked. A fine inked line is an indication that the plant is shut down.

Mine Conveyors—Recording voltmeters, rather than ammeters, are employed in the mines of other coal companies primarily to post mine delays and incidentally to record mine voltage. The instrument is connected in the feed line to a centrally located, underground, loading conveyor over which all the mined coal passes. When the conveyor is not in service there is, naturally, no voltage to record, but each time the conveyor is put in use the fact is recorded on the instrument chart by a sharply radiating load line. Owing to the necessarily frequent and sudden starts and stops of the conveyor, as well as to variances in load, a veritable sunburst of rays traced by the swing of the recording pen is formed, breaks in which, as indicated by the directional arrows shown about the circumference of the typical chart illustrated in Fig. 5, are signs of mine delays, which are often marked in key colors to register the cause or reason for the interruptions.

Thus, by the exercise of a little ingenuity and wise planning much can be accomplished through the use of electrical recorders, with substantial savings realized and time conserved.

1



3

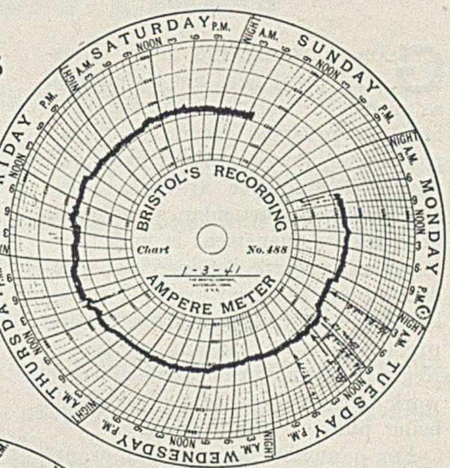
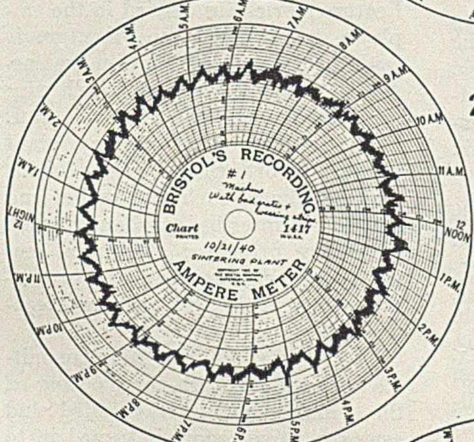
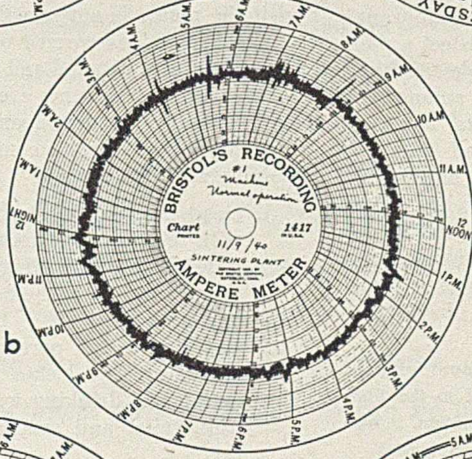


Fig. 1—Sugar crystallizer load record shows progress of crystallization

Fig. 3—Ammeter records assist this mill to secure a uniform product at lower cost



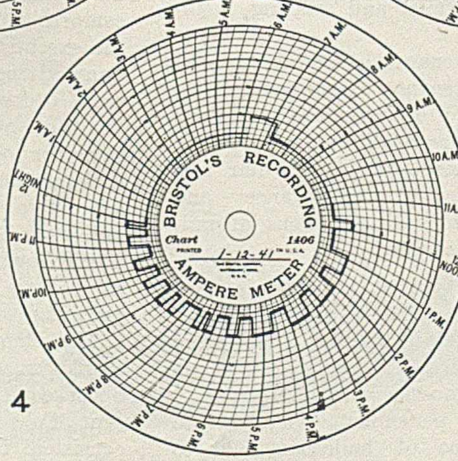
2a



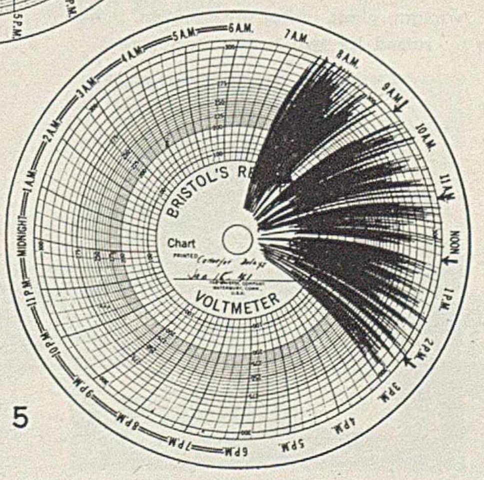
2b

Fig. 2a—Fluctuations in sintering plant load were traced to faulty equipment

Fig. 2b—After repairs sintering plant load became much more uniform



4



5

Fig. 4—Recording ammeter serves as automatic time keeper at coal washery

Fig. 5—Voltage fluctuations show mine conveyor delays; note arrows identifying delay causes

Charts courtesy The Bristol Co.

A Plan for Industrial Good Housekeeping

FELIX N. WILLIAMS
Production Manager, Phosphate Division, Monsanto Chemical Co.

Chem. & Met. INTERPRETATION

Inter-plant good-housekeeping competition is the Monsanto Co.'s method of promoting cleanliness in its numerous plants. An annual award is made to two having the best records. Improvement of cleanliness and orderliness is a means, not an end in itself. Improved safety records, employee morale and increased production are the result of such campaigns. The scheme outlined here might even be applied on an inter-departmental basis in small plants.—*Editors.*

Good housekeeping in an industrial plant need not be justified as an end in itself. It is, on the other hand, a practical means to higher production, lower accident rates and improved employee attitude. These facts are of particular significance now when management is under tremendous pressure for increased production and the need for good housekeeping is apt to be overlooked in the press of more urgent problems. Neglect of this problem now would work toward the defeat of the ends being pursued so strenuously.

For a number of years Monsanto Chemical Co. has had in effect a plan to encourage good housekeeping by stimulating competition among the Company's domestic plants. The competition is on a year round basis but ratings are obtained by annual inspection visits. The plants are classified into two groups according to size in order to equalize conditions among them and to avoid placing a plant employing 1,000 men in direct competition with one employing 150 men.

Last year the Monsanto pennant for good housekeeping was awarded to the Shawinigan plant. After presentation, it was raised by two veteran employees

The annual inspection is carried out by two boards, one for each plant group. Each board consists of a general staff executive as chairman, at least one plant operating man of plant manager or assistant plant manager rank and at least one man from a divisional personnel, engineering or research department. At least one man on each committee is drawn from the board of the previous year. The inspection visits are made at a time not announced previously and the order in which they are to visit the plants is not revealed.

The inspections carried out by the committees are detailed and thorough. Every department and every building in every plant is seen and examined by the entire committee. Six points are scored:

1. Good housekeeping which deals with cleanliness, neatness and orderliness of buildings, laboratories, first-aid or medical rooms, and grounds.
2. Sanitation and personnel services including locker facilities, eating and drinking water facilities, toilet and washing facilities.
3. Maintenance of buildings.
4. Maintenance of equipment.
5. Control of obnoxious or tedious working conditions.
6. Personnel, with particular reference to appearance and amount and conditions of uniform clothing.

Each committee member is supplied with a sheet on which he records his detailed scores. Each of six general heads is weighted, 200 points to good housekeeping, 120 to sanitation and personnel services, 120 to maintenance of buildings, 320 to maintenance of equipment, 100 to control of working conditions and 140 to personnel, making a maximum score of 1,000 for each plant. Each of these general headings is broken down into a number of subheads which are assigned weights in accordance with their importance.

The scoring is based on those factors which are controllable by local management and on the condition and use of available equipment. Also taken into consideration is the nature of the products produced or handled, since it is easier to keep a pharmaceuticals plant clean, for instance, than making lampblack.

The committee members make out their score sheets and turn them in to the committee secretary immediately after each plant visit. These are neither revealed nor discussed by the committee as a whole until the final general review. One committee member does not know how the other members scored each plant nor does he know the relative ratings of the plants until the tour is completed. At the end of the trip a general review is held by each committee and the score of each plant is averaged to give a plant score. From these scores the winning plant in each group is chosen.

A number of steps are taken to give recognition to the winning plant. Feature stories are carried in the employee house organ, and mention is made in the general house magazine. A star pennant is awarded each winning plant and flown from its staff. Each employee of a winning plant receives a worthwhile souvenir for his accomplishment such as a wallet and key set or inscribed pen and pencil. These are presented at general employee meetings at which the presentations are made by a ranking executive officer.

The work of the inspection committee does not end with the choosing of the winning plant. A detailed and comprehensive report is turned in to the executive committee of the company giving specific reasons for all point deductions. These reports take the form of criticisms, recommendations for local management and general recommendations. The reports are forwarded to local management and form a plan for improvement. The following year the report serves as a basis for comparison for the next inspection committee.

The plan has been definitely successful in raising the level of good housekeeping throughout the Monsanto Co.'s plants. Every year brings consistent improvement.

CHEM & MET REPORT ON

Fire Protection Methods For Process Plants

TO EXECUTIVES AND ENGINEERS IN PROCESS INDUSTRY PLANTS

Now that the war materials plants of the United States are largely built, and it is raw materials and shipping facilities that are becoming the bottlenecks, conservation of production facilities and the raw materials stored and ready for use emerges as a matter of vital necessity. If the hazards of enemy action still seem remote within the continental borders of the country, nevertheless, there is a much older and more subtle enemy — fire — which is never remote. Times of stress only increase its avidity and redoubled vigilance is required as the price of fire-safety. On this account, *Chem & Met* takes this opportunity to remind its readers of the ever-present hazard, not so much from bombs and saboteurs, as from normal fire causes, accelerated by the pace of the times. In the report which follows we attempt to high-spot the best in protection methods, to outline procedure in organizing and training a plant fire brigade, and to show interested engineers where further information can be had.

Fire Protection Methods For Process Plants

SUMMARY AND CONCLUSIONS

So much has been published in recent months on the special fire hazards of war-time that it seems possible that the ordinary peace-time fire hazards of the chemical process industries may not be receiving quite the attention that they deserve. On that account this report has been prepared, both to discuss the normal hazards, and to show how fires may be fought. In addition, the report goes briefly into the organization and training of the plant fire brigade, and into sources of information on industrial fire hazards, fire prevention and protection.

Several agencies, notably the National Fire Protection Association and the Factory Mutual Fire Insurance Cos. Inspection Department, have cooperated with the editors in supplying the most recently available information. Other agencies also, as noted herein, are available for advice and assistance to the end that industrial fire losses be minimized in these critical days when every pound of production is vitally needed, and every building and piece of equipment lost may be difficult if not impossible to replace.

FIRE PREVENTION, the goal of all who are concerned with the avoidance of losses of life and property through fires, can rarely be completely achieved in industry, no matter how closely it may be approached through exercise of eternal vigilance, and the use of every possible precaution. Engineers in every process industry are thoroughly familiar with numerous fire prevention methods applying to their ordinary as well as their special hazards. Many thousands of dollars are spent annually on fire prevention. Nevertheless, fires still occur and will doubtless continue to occur, so long as human failure and improper functioning of mechanical contrivances are possible. Fire prevention alone is not enough. With the best in prevention must go the best in protection. To the latter aim this report is dedicated.

A fact of great importance in considering the fire hazards of chemical process industries is that, more frequently than not, fire arises in most of these industries from ordinary rather than from special hazards, since the latter are more feared, and therefore more carefully guarded against. Partly for this reason but also because special hazard fires in the majority of cases will respond satisfactorily to the same procedures if they are properly chosen and used, the principal emphasis of what follows will be given to the ordinary extinguishment methods which are in best repute today.

Unfortunately, space is lacking for an adequate discussion of the hazards peculiar to the various industries of the process group. Considerable information can be found in the literature, although much of it has been written from the standpoint of the insurance inspector rather than that of the chemical engineer or industrialist. (See Table II on information sources.) In lieu of such a detailed discussion, Table I is presented, which is a condensation of a much more extensive tabulation prepared by the Factory Mutual Inspection Dept. Somewhat similar tabulations (one in the same, and one in much greater detail on fewer materials) can be found in the Crosby-Fiske-Forster Handbook of Fire Protection (see Table II).

EXTINGUISHMENT MATERIALS

Only a relatively few materials are used for fire extinguishment, but there are many ways of applying them. Water is by far the most important agent, and is said to be effective in 85 percent of all fires. It may be used alone, either as a solid stream or as a coarse or a fine spray, all of which have different fire extinguishing properties. It may be mixed with foaming ingredients to produce a fire-smothering blanket, or it may have chemicals added to produce a stream-expelling reaction, to yield enhanced extinguishing properties, or to prevent freezing in cold weather. As a solid stream or coarse spray it is effective on fires in ordinary combustibles where the cooling and quenching effects are chiefly required. As a fine spray it is effective on electrical fires (since in this form it is non-conducting), and on some flammable liquids with which it is immiscible.

In addition to water, the other extinguishing media used in any considerable quantity include carbon dioxide, carbon tetrachloride and a dry powder based largely on sodium bicarbonate. Steam is occasionally used, and magnesium fire hazards have recently made a place for new extinguishing solids including a proprietary power based on graphite, a special granular pitch, and granular feldspar. To some extent a number of the older solid extinguishing materials are still used, including sand, soda, salt, sawdust and talc.

HAND EXTINGUISHERS

Fire-fighting methods may be classified under the headings of (1) first-aid equipment; (2) permanently piped systems; and (3) large-scale portable equipment. This last class is the type employed by the regular fire company and is in reality a subdivision of Class (2) in that the fire-fighting medium is generally obtained from a permanently piped source of supply.

First-aid extinguishers are credited with the control of well over half of all fires. They are obtainable employing all of the types of extinguishing media previously mentioned. Among the simplest types are water buckets, bucket tanks and sand buckets. The standard bucket for fire use holds 12 qt. and is provided with a loose-fitting cover to prevent evaporation. If there is danger of freezing, a calcium chloride solution of the desired freezing point can be employed instead of water.

Probably more effective than the ordinary water bucket is the bucket tank or barrel which holds from 25 to 50 gal. A common arrangement is to nest six pails inside the tank. One type of pail has a counterweighted handle designed to rise into lifting position when the next higher pail is removed with its filling of water. Bucket tanks are generally equipped with a tight-fitting cover and rubber gasket.

Pump Tanks—A pump tank is a cylindrical vessel, closed at the top and built in 2½ and 5 gal. sizes. The tank is equipped with a carrying handle and a pump with a length of hose, capable of throwing a stream 35–40 ft. If desired, a non-freezing calcium chloride solution can be used. This equipment is suitable for fires in ordinary combustibles and is particularly useful for extinguishing fires overhead which would be difficult to reach with a fire bucket.

Soda-Acid Extinguishers—The soda-acid extinguisher is the most commonly employed type. It is built in sizes ranging from 1¼ to 2½ gal. and consists of a vertical cylindrical pressure tank containing a charge of dilute sodium bicarbonate solution (1½ lb. in 2½ gal.) and a suspended bottle holding 66 deg. Bé. sulphuric acid (4 fl. oz. per 2½-gal. extinguisher). When the extinguisher is inverted, the acid mixes with the bicarbonate solution, producing a pressure of carbon dioxide gas, which is capable of discharging the contents of the extinguisher over a distance of 30–40 ft. for a period of about 1 minute. This type is also supplied in a wheeled model for industrial use, having a capacity of 20 or 40 gal., and throwing a stream 45–60 ft. for 3–5 minutes. Soda-acid extinguishers are used for fires in ordinary combustible materials but are unsuitable for flammable liquids and electrical equipment.

Gas Cartridge Extinguisher—One type of extinguisher which has been used in recent years in the 2½ gal. size is similar in appearance to the soda-acid extinguisher but uses plain water or calcium chloride anti-freeze solution as the filling and is provided with a cartridge of compressed carbon dioxide gas which supplies the necessary pressure for expelling the liquid. The extinguisher is operated by striking the top against the floor, causing a pin to puncture a seal in the cartridge and thus release the carbon dioxide. Performance and use are substantially similar to the soda-acid type.

Non-Freezing Extinguishers—As already noted, both the pump tank and the carbon-dioxide-powered water extinguisher can be provided with anti-freeze solutions. Another type of anti-freeze extinguisher has a bottle of sulphuric acid and a special potassium carbonate solution in a small inner container. The extinguisher proper is filled with calcium chloride solution. When the extinguisher is inverted, mixture of the acid with the carbonate solution forms sufficient carbon dioxide pressure to expel the calcium chloride solution. The acid in this extinguisher is protected by sealing with a layer of non-volatile liquid to prevent absorption of water vapor and raising of the freezing point.

Loaded Stream Extinguisher—This is a type of anti-freeze extinguisher made in 1–2½ gal. sizes, containing a special solution of alkali metal salts, the propelling pressure being provided either by a carbon dioxide cartridge or by a chemical reaction. These salts exert a special extinguishing action. On Class A fires they extinguish the flame rather suddenly and produce a fireproofing effect. On Class B fires, without blanketing the fire, they nevertheless produce a chemical action, tending to inhibit oxidation.

Foam Extinguishers — Hand-type foam extinguishers come in 1¼ or 2½ gal. sizes and are similar in appearance to the soda-acid type. Larger portable foam extinguishers are made in 10, 20 and 40 gal. sizes. In all of these the main tank holds a solution of sodium bicarbonate to which a foaming agent has been added. A secondary tank mounted inside the first is a long metal tube containing a solution of aluminum sulphate. When the extinguisher is inverted, the reaction between the aluminum sulphate and the bicarbonate solution produces carbon dioxide gas, which under the influence of the foaming agent, produces a foam having about 7½ to 8½ times the volume of the original solution. The pressure of the gas projects the foam from the hose a distance of about 35-45 ft. for the 2½ gal. extinguisher.

Foam forms a blanket which floats on the surface of most liquids, persisting for some time and thus preventing re-ignition of the fire. Ordinary foam, however, is relatively ineffective on fires in liquids such as alcohols, acetone, butyl and amyl acetates. These liquids are partly or completely soluble in water and apparently tend to cause partial or complete disintegration of the foam. Several manufacturers now supply special foam producing chemicals especially for such hazards. These chemicals are, however, approved only for use in the so-called single-powder generators referred to below, and not for first-aid equipment.

Foam is a good conductor of electricity and must not be used on live electrical apparatus. It is not as well suited to fires in ordinary combustible materials as water extinguishers. Foam solutions are not freeze-proof and therefore should not be exposed to freezing temperatures.

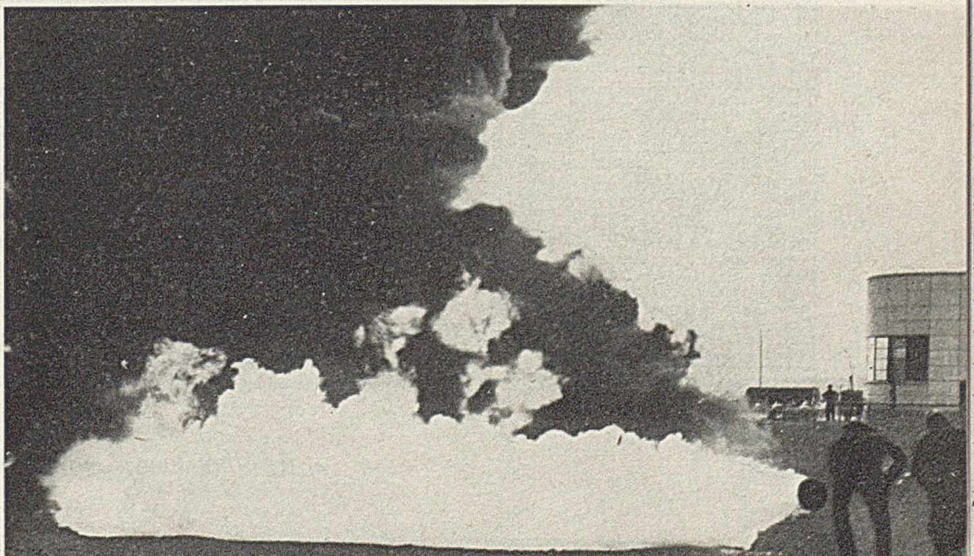
Carbon Dioxide — Portable carbon dioxide extinguishers are made in nine sizes ranging from 2 to 100 lb. of CO_2 capacity. These are all of the high pressure type in which the carbon dioxide is stored as a liquid at a pressure of about 850 lb. per sq. in. at normal temperature. Tank-truck type carbon dioxide equipment is also available in much larger capacities (3 tons) with the liquid CO_2 maintained at a temperature of about 0 deg. F. by means of refrigeration and at a pressure of about 300 lb. The latter type is used in the fighting of airport and certain industrial fires.

The ordinary portable CO_2 extinguisher consists of an I.C.C. approved steel cylinder fitted with a quick-opening valve and a length of high pressure flexible hose terminating in a specially designed discharge assembly and conical fiber horn to provide for proper expansion of the gas. In the 2-lb. type, a swivel tube is provided instead of a flexible hose. These units discharge a combination of carbon dioxide gas and snow, having an effective range of from 2 to 8 ft. and a continuous discharge of from 15 to 110 sec. depending upon the size of the extinguisher. Most extinguishers of recent design can be discharged intermittently. This method of extinguishment operates by blanketing the fire with a heavy inert gas, thus depriving it of the oxygen required for combustion. In addition, a small amount of cooling is accomplished, since the snow is at a temperature of −110 deg. F.

Carbon dioxide is non-injurious, non-corrosive and a non-conductor of electricity. Such extinguishers will not freeze nor does the contents deteriorate with age. Carbon dioxide can be used for extinguishing fires in small quantities of flammable liquids and is particularly suited to applications which break down foam. This material is also well adapted for electrical fires.

Carbon Tetrachloride—The so-called vaporizing liquid extinguisher employs a specially prepared carbon tetrachloride, treated to remove corrosive substances and to lower its freezing point. Ordinary carbon tetrachloride should never be used in such extinguishers. Extinguishers range in size from 1 qt. to 3 gal. They operate by reason of the heavy vapor formed when CCl_4 vaporizes, blanketing the fire. The cooling effect of the evaporation is less than with water. Three types of vaporizing liquid extinguisher are available including the pump type, the air pressure type and the carbon dioxide pressure type. Pump type extinguish-

Carbon dioxide discharged at a high rate from a Cardox bulk storage fire truck built for Cramp Shipbuilding Co. rapidly deals with a gasoline fire



ers are made in sizes from 1 qt. to 2 gal. and consist of a container with an integral pump for discharging the liquid. The air pressure type is built in sizes from 1 to 3 gal. and contains a pump by means of which air at a pressure of 100 lb. per sq. in. can be stored in the extinguisher, ready to discharge the liquid when needed. Such extinguishers are equipped with a pressure gage and should be inspected periodically to detect loss of pressure. The third type, made only in the 1 qt. size, contains carbon dioxide gas under pressure above the surface of a mixture of carbon tetrachloride and methyl bromide. When the valve is opened the liquid discharges. Extinguishers of the vaporizing liquid type are particularly suitable for use on electrical apparatus and also on flammable liquid fires in confined spaces. They should not be used, however, where the operator will be unduly exposed to the fumes liberated, since carbon tetrachloride breaks down at high temperature to some extent, forming toxic gases.

Dry Chemical Extinguishers—The only approved dry chemical extinguisher at present manufactured in the United States employs a specially prepared sodium bicarbonate mixed with other materials to prevent caking, which is discharged from the apparatus through a hose under pressure of carbon dioxide or nitrogen gas released from a sealed metal cartridge. When operated, these extinguishers discharge a heavy cloud of dust on to the burning material, blowing away the flame and smothering the fire. The hand type, which resembles a soda-acid extinguisher, employs a sealed cartridge containing 6¼ oz. of carbon dioxide. In operation this is pierced by turning down a handwheel at the top and the carbon dioxide expels the powder through a hose. In the wheeled type, a steel tank holding 150-350 lb. of chemical is mounted on a carrier, together with a cylinder of nitrogen to force the dry chemical through a 50-ft. hose. Extinguishers of this type are suitable for use on flammable liquids in open tanks or on

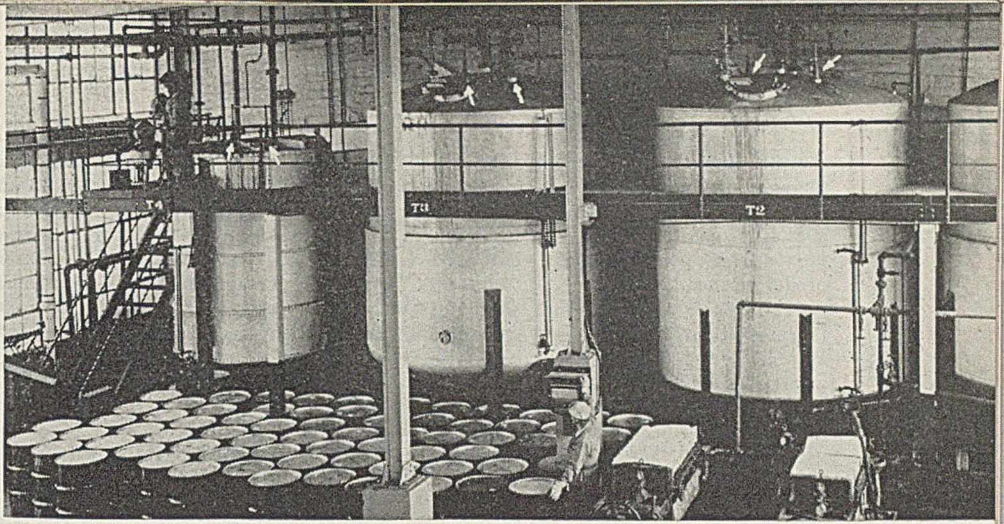
Table I—Properties of Flammable Materials

(Condensed by permission from Factory Mutual Data Sheet No. 36.10 (Jan. 1940), published by Inspection Dept., Associated Factory Mutual Fire Ins. Cos. Note: Numbers in parentheses after material name indicate suitable extinguishing agents. (1) Water; water spray behaves differently from solid stream, in general being suitable for fires in flammable liquids having flash point above 150 deg. F. (2) Foam. (3) Carbon dioxide. (4) Dry chemical. Asterisk (*) indicates material subject to spontaneous heating.)

Name	Flash Point, Deg. F.[1]	Explos. Range, %[2]	Auto-ignition Temp., Deg. F.	Sp. Gr., Water =1	Vapor Density, Air=1
Acetaldehyde (1,3,4)	-17	4.0 -57.0	365	0.783	1.52
Acetic Acid (Glacial) (1,3,4)	104	4.0 -....	1050	1.05	2.07
Acetic Anhydride (1,3,4)	121	... -....	752	1.08	3.52
Acetone (3,4)	0	2.15-13.0	1118	0.792	2.00
Acetyl Chloride (1,3,4)	40	... -....	...	1.105	2.70
Aldol (1,2,3,4)	181	... -....	...	1.11	3.04
Allyl Alcohol (3,4)	70	3.0 -....	713	0.854	2.00
Amyl Acetate-n (3,4)	76	1.1 -....	714	0.879	4.49
Amyl Alcohol-prim. iso (3,4)	109	... -....	667	0.813	3.04
Aniline (2,3,4)	168	... -....	1418	1.022	3.22
Anthracene (1,2,3,4)	250	0.63-....	881 in O_2	1.25	1.15
Anthraquinone (1,2,3,4)	365	... -....	....	1.438	7.16
Asphalt (Typical) (1,2,3,4)	400+	... -....	905	0.95-1.1	....
Benzaldehyde (1,2,3,4)	148	... -....	....	1.05	3.66
Benzene (2,3,4)	12	1.4 - 8	1076	0.88	2.77
Benzoic Acid (1,3,4)	250	... -....	....	1.266	4.21
Benzyl Acetate (1,2,3,4)	216	... -....	862	1.06	5.17
Benzyl Alcohol (1,2,3,4)	213	... -....	817	1.04	3.72
Benzyl Chloride (1,2,3,4)	140	1.1 -....	....	1.103	4.36
Bromobenzene (1,2,3,4)	149	... -....	....	1.497	5.41
Butyl Alcohol-n (3,4)	84	1.7 -....	693	0.806	2.55
Butylene Glycol (3,4)	104	... -....	....	1.019	3.10
Butyl Lactate (2,3,4)	160	... -....	....	0.968	5.04
Butyl Propionate-n (2,3,4)	90	... -....	800	0.875	5.00
Butyraldehyde (3,4)	20	... -....	....	0.817	2.48
Butyric Acid-n (1,3,4)	170	... -....	....	0.960	3.04
Camphor (1,2,3,4)	150	... -....	871	0.999	5.24
Carbitol (1,3,4)	201	... -....	....	0.99	4.62
Carbitol Acetate (1,3,4)	225	... -....	....	1.013	6.07
Carbon Disulphide (1,3,4)	-22	1.0 -50	257	1.256	2.64
Carnauba Wax (1,3,4)	540	... -....	....	....	....
Castor Oil* (1,2,3,4)	445	... -....	840	0.96	....
Cellosolve (3,4)	104	2.6 -15.7	460	0.931	3.10
Chlorobenzene (2,3,4)	90	... -....	....	1.11	3.88
Coal Tar Pitch (1,2,3,4)	405	... -....	....	....	....
Cocoanut Oil* (1,2,3,4)	420	... -....	....	0.91	....
Corn Oil* (1,2,3,4)	490	... -....	....	0.92	....
Cottonseed Oil* (1,2,3,4)	590	... -....	650	0.925	....
Creosote Oil (1,2,3,4)	165	... -....	637	>1	....
o-Cres ' (1,2,3,4)	178	... -....	....	1.05	3.72
p-Cresol (1,3,4)	187	... -....	....	1.04	3.72
Crotonaldehyde (3,4)	55	2.95-15.5	....	0.853	2.41
Cyclohexane (2,3,4)	1	1.31- 8.35	....	0.779	2.90
p-Cymene (2,3,4)	117	... -....	921	0.86	4.62
Denatured Alcohol—95% (3,4)	60	... -....	....	0.82	1.60
Diacetone Alcohol (comm'l) (3,4)	48	... -....	....	0.931	4.00
Dibutyl Ether-n (3,4)	77	... -....	....	0.769	4.48
Dibutyl Phthalate-n (1,2,3,4)	315	... -....	....	1.045	9.58
o-Dichlorobenzene (1,2,3,4)	151	... -....	....	1.325	5.07
p-Dichlorobenzene (1,3,4)	150	... -....	....	1.458	5.07
Diethanolamine (1,3,4)	....	... -....	1224	1.097	3.65
Diethyl Carbitol (1,3,4)	....	... -....	....	0.908	....
Diethyl Carbonate (2,3,4)	77	... -....	....	0.977	4.07
Diethylene Glycol (1,3,4)	255	... -....	444	1.119	3.66
Diethylene Oxide (3,4)	65	1.97-22.2	....	1.035	3.03
Diethyl Ether (3,4)	-20	1.7 -48.0	366	0.71	2.55
Diethyl Sulphate (1,2,3,4)	220	... -....	....	1.184	5.31
Dimethyl Aniline (1,2,3,4)	145	... -....	700	0.956	4.17
Dimethyl Ether (3,4)	-42	... -....	....	....	1.617
Dimethyl Sulphate (1,2,3,4)	182	... -....	....	1.332	4.35
Dinitro Toluene-2, 4 (1,3,4)	....	... -....	....	1.52	6.27
Diphenyl (1,3,4)	235	... -....	....	1.041	5.31
Diphenylamine (1,3,4)	307	... -....	....	1.16	5.82
Diphenyl Oxide (1,2,3,4)	239	... -....	....	1.073	5.86
Divinyl Ether (3,4)	<-22	1.7 -27.0	680	0.774	....
Ethanolamine (1,3,4)	....	... -....	....	1.02	2.10
Ethyl Acetate (3,4)	24	2.18-11.5	907	0.899	3.04
Ethyl Acetoacetate (1,3,4)	184	... -....	....	1.03	4.48
Ethyl Alcohol (3,4)	55	3.28-19	799	0.79	1.59
Ethyl Benzene (2,3,4)	59	... -....	....	0.868	3.66
Ethyl Butyrate (3,4)	78	... -....	....	0.879	4.00
Ethyl Chloride (3,4)	-58	3.6 -14.8	....	0.910	2.22
Ethylene Diamine (3,4)	93	... -....	....	0.890	2.07
Ethylene Dichloride (1,2,3,4)	56	6.2 -15.9	775	1.258	3.42
Ethylene Glycol (3,4)	232	... -....	775	1.113	2.14
Ethylene Oxide (3,4)	....	3 -80	804	0.887	1.52
Ethyl Formate (2,3,4)	-4	3.5 -16.5	....	0.922	2.55
Ethyl Lactate (3,4)	115	... -....	....	1.03	4.41
Furfural (1,2,3,4)	140	2.1 -....	739	1.159	3.31
Gasoline (2,3,4)	-50	1.3 - 6	495	0.75	3-4
Glycerine (1,3,4)	320	... -....	739	1.26	3.17
Hydroquinone (1,3,4)	329	... -....	....	1.332	3.81
Kerosene (2,3,4)	100-165	... -....	490	<1	....
Linseed Oil* (1,2,3,4)	435	... -....	820	0.93	....
Lubricating Oil, Cylinder (1,2,3,4)	....	... -....	783	<1	....
Menhaden Oil* (1,2,3,4)	435	... -....	828	0.927	....
Methyl Acetate (3,4)	15	4.1 -13.9	935	0.925	2.56
Methyl Alcohol (3,4)	54	6.0 -36.5	878	0.792	1.11
Methyl Amine (3,4)	0	... -....	....	0.699	....
Methyl Butyrate (2,3,4)	57	... -....	....	0.898	3.52
Methyl Carbitol (1,3,4)	....	... -....	....	1.035	4.14
Methyl Cellosolve (3,4)	107	... -....	551	0.966	2.62
Methyl Ethyl Ether (3,4)	-35	2 -10.1	374	0.697	2.07
Methyl Ethyl Ketone (3,4)	30	1.81-11.5	....	0.805	2.41
Methyl Formate (3,4)	-2	5.0 -22.7	840	0.975	2.07
Methyl Salicylate (1,2,3,4)	214	... -....	850	1.182	5.24
Naphtha, Safety Solvent (2,3,4)	100-110	1.1 - 6.0	450-500	<1	....
Naphtha, V. M. & P. (2,3,4)	20-45	1.2 - 6.0	450-500	<1	....
Naphthalene (1,3,4)	174	0.9 -....	1053	1.145	4.42
Naphthol, beta (1,3,4)	307	... -....	....	1.22	4.97
p-Nitroaniline (1,3,4)	390	... -....	....	1.437	....
Nitrobenzene (1,2,3,4)	190	... -....	924	1.2	4.25
p-Nitrotoluene (1,3,4)	223	... -....	....	1.286	4.72
Oleic Acid* (1,2,3,4)	372	... -....	685	0.891	....
Olive Oil* (1,2,3,4)	437	... -....	826	0.910	....
Ozokerite (1,3,4)	236	... -....	....	0.95	....
Palm Oil* (1,2,3,4)	421	... -....	650	0.92	....
Paraffin Wax (1,3,4)	390	... -....	473	0.9	....
Paraformaldehyde (1,3,4)	158	... -....	....	....	....
Pentane-n (2,3,4)	<-40	1.4 - 8.0	588	0.631	2.48
Perilla Oil* (1,2,3,4)	522	... -....	....	0.93	....
Petroleum, Crude (2,3,4)	20-90	... -....	....	<1	....
Phenol (1,3,4)	175	... -....	1319	1.07	3.24
Phenyl Cellosolve (3,4)	....	... -....	....	1.109	....
Phosphorous (Red) (1)	....	... -....	500	2.30	....
Phosphorous (Yellow) (1)	....	... -....	86	1.82	....
Phthalic Anhydride (1,3,4)	305	... -....	....	1.527	5.10
Picric Acid (1)	Explodes	... -....	<572	1.763	7.90
Pine Oil* (1,2,3,4)	172	... -....	....	0.86	....
Pine Tar* (2,3,4)	130	... -....	671	....	....
Propyl Acetate-n (2,3,4)	58	2.0 -....	....	0.886	3.52
Propyl Acetate-iso (2,3,4)	43	2.0 -....	860	0.877	3.52
Propyl Alcohol-n (3,4)	59	2.5 -....	812	0.804	2.07
Propyl Alcohol-iso (3,4)	53	2.5 -....	852	0.789	2.07
Propyl Alcohol-sec (3,4)	67	... -....	....	0.79	2.07
Pyridine (3,4)	68	1.8 -12.4	1065	0.982	2.73
Rape Seed Oil* (1,2,3,4)	325	... -....	836	0.915	....
Resorcinol (1,3,4)	261	... -....	....	1.272	3.79
Soya Bean Oil* (1,2,3,4)	540	... -....	833	0.925	....
Stearic Acid* (1,3,4)	385	... -....	743	0.847	9.80
Sulphur (1)	405	... -....	450	2.046	....
Sulphur Chloride (1,3,4)	245	... -....	453	1.687	3.31
Tannic Acid (1)	....	... -....	....	....	....
Tartaric Acid (1)	....	... -....	....	1.667	....
Toluene (2,3,4)	40	1.27- 7.0	1026	0.866	3.14
o-Toluidine (1,2,3,4)	185	... -....	900	0.999	3.90
p-Toluidine (1,3,4)	188	... -....	900	0.973	3.90
Triethanolamine (1,3,4)	355	... -....	....	1.13	5.14
Tung Oil* (1,3,4)	552	... -....	855	0.94	....
Turpentine* (2,3,4)	95	0.8 -....	488	<1	....
Vinyl Acetate (2,3,4)	18	... -....	800	....	....
Vinyl Chloride (3,4)	....	4 -22	....	0.97	2.15

[1] Closed cup method. [2] Range from lower to upper limit, percent by volume in air.

the floor, as well as for ordinary fires in electrical equipment. However, the material should carefully be removed from electrical contact surfaces after the fire. This method has a maximum range of about 10 ft., thus limiting such extinguishers to relatively small fires where re-ignition is not likely to take place.



Kidde carbon dioxide nozzles permanently installed in these tanks (nozzles shown by arrows) protect the plant against flammable solvent hazard

PERMANENT SYSTEMS

Standpipes—A usual method of protection inside buildings is to provide one or more standpipes, often installed in stair wells, with a hose outlet at each floor level. A standpipe system designed for use of the occupants of the building generally employs 1½ or 1¼ in. hose with a ⅜ or ½ in. nozzle. A standpipe for use by the plant or municipal fire department has 2½ in. outlets. The first type is equipped with hose and a nozzle permanently installed. With the second type, the hose is generally not kept attached but is brought in by the fire department.

Hose—Fire hose is made in two general types, (1) rubber-lined, cotton-covered and (2) linen hose without lining. The first type is employed by both plant and municipal fire departments, while the second type, because it does not deteriorate in storage inside buildings as long as it is kept dry, is used for permanent attachment to standpipes. Rubber-lined cotton hose is made in 1½ and 2½ in. sizes with single, double and triple jackets, the heavier grades being for rough usage. For use around corrosive liquids or in corrosive atmospheres, a rubber-covered type is available. After use, rubber-lined hose must be cleaned and carefully dried before storing away. The standard length is 50 ft. Each length of hose is equipped with standard couplings having a swivelling threaded section operated by a special spanner. Today practically all plant fire connections are of the same thread standard used by municipal agencies.

Hose Houses—For outside use around the plant, hose houses are often built over hydrants. At least 100-150 ft. of 2½ in. rubber-lined hose, should be permanently attached to the hydrant and supported on a shelf, so folded forward and backward as to ventilate properly. A second shelf will carry two or more additional rolls of hose. In addition, the plant fire department may be equipped with one or more hose carts carrying up to 500 ft. of 2½ in. rubber-lined hose. Carts should be stored in an outside building, such as a small, ventilated cart house.

Nozzles—The standard 2½ in. play pipe is a nozzle 30 in. long, equipped with a 1⅛ in. cylindrical orifice. Two handles are provided to assist in holding the nozzle. Other types include the lever-shut-off type, having a valve by means of which the stream can be shut off. Several spray nozzles are built, one kind being capable of producing a spray discharge angle anywhere in the range between 40 and 150 deg. One nozzle which throws a solid stream is adjustable to change the size of the stream between 1¼ and ½ in. The type known as the monitor nozzle is intended for permanent installation in outdoor locations where large amounts of combustible material are stored, for example, log piles at pulp mills. This nozzle is connected directly to the piping, and is designed to swivel in any direction desired.

SPRINKLERS

Generally speaking, sprinklers are the most effective type of fire-fighting system for use where water can be employed. They are of numerous types. The ordinary overhead sprinkler employs many different kinds of sprinkler nozzles, as well as several different arrangements for bringing water to the nozzles. In addition, there is the fog type which has in recent years been found effective as a permanent installation for the extinguishment of both electrical fires and fires in flammable liquids. Sprinklers are also used for outside installation, under cornices, over windows, and on roofs, for the exposure protection of buildings.

Overhead Sprinklers—Sprinklers are almost always automatically operated, either through a fusible device installed in each sprinkler head or through a thermostat which opens the valve supplying the water. Water is fed to the sprinkler through a system of piping ordinarily attached to the ceiling, with sprinklers placed at intervals along the pipe, generally at a spacing of 80 sq. ft. per sprinkler. Heads should be placed in an upright position, unless a special pendant type is employed. Where the proper water supply is available, sprinklers have shown a remarkable record of effectiveness in fire control.

Depending on the ambient temperature, sprinklers are available to operate at various fixed temperatures ranging between 135 and 500 deg. F. Three methods of actuation of automatic sprinkler heads are employed: (1) The solder type, making use of a fusible link; (2) the bulb type employing a quartz glass bulb nearly filled with a liquid which expands as the temperature rises, eventually shattering the bulb at the operating temperature; and (3) the chemical type which has a small cylinder containing a low-melting chemical which fuses at the desired temperature. Standard sprinkler heads have either a ½ in. ring type discharge orifice or a $\frac{7}{16}$ in. tapered nozzle orifice. The orifice is ordinarily closed by a disk which is held tightly in place by means of the fusible or frangible element.

Sprinkler systems are of two general kinds including the wet-pipe and the dry-pipe types. In the wet-pipe system, the distribution piping is under water pressure at all times. In the dry-pipe system, the piping is maintained under an air pressure of 15 to 40 lb., the air pressure serving to keep the water valve closed. The dry-pipe type is employed where there is a possibility of freezing. Sometimes, in this case, a wet-pipe system is provided, using an anti-freeze liquid such as a calcium chloride or a glycol or glycerine solution. The wet-pipe type is set into operation by the fusing of one or more of the sprinkler heads, whereupon water immediately issues, rushing against a deflector which sprays it effectively over a considerable area. In the dry-pipe type, fusing of a sprinkler head permits the escape of the air which, when the pressure drops sufficiently, allows the water valve to open, after which the water flows through the pipe and out of the fused sprinkler head. The dry-pipe type, therefore, has a short lag which sometimes makes this system undesirable. In some dry-pipe systems, the automatic water valve is designed to use relatively low air pressure, thus resulting in a shorter lag.

Deluge Systems—For hazards requiring large amounts of water over the entire area in which a fire may originate, the so-called deluge system is employed. This makes use of a group of open sprinkler heads which are generally controlled by a thermostat. The method is used in extreme hazards where water damage is not likely to be a serious factor. Automatic control is provided either by fixed-temperature thermostats which function when the temperature reaches a certain elevation, or by a rate-of-rise system which goes into operation only when the temperature rises more rapidly than at a predetermined rate.

Pre-Action System—One type of thermostatically controlled sprinkler system designed particularly for use where there is danger of serious water damage is known as the pre-action system. In this method the pipes are normally dry. The action of a thermostat releases a pre-action valve, the water fills the piping system and an alarm is given in advance of the fusing of the sprinkler heads. Frequently the sounding of the alarm gives an opportunity to extinguish the fire by hand before the sprinklers go into operation. On the other hand, should one or more sprinkler heads fuse immediately, this system obviates most of the operating delay of the ordinary dry-pipe system.

Sprinkler Alarms—Sprinkler systems are customarily equipped with a water-flow alarm which is designed to give warning of the sprinkler's operation the instant water flow starts. Both water motor alarms and electric actuated alarms are used. The electric alarm has the advantage that it is able to transmit a warning over any desired distance.

Fog and Spray Systems—Although water which does not contain foam-forming chemicals is not ordinarily considered as suitable for use on flammable liquids with which it is not miscible, nevertheless in recent years excellent results have been obtained with spray producing nozzles. An example is the so-called Mulsifyre projector originally developed in England which discharges water in the form of a well distributed spray. This strikes with considerable force on the surface of the liquid being protected and is stated to form a temporary oil-in-water emulsion. Such projectors are connected to specially designed pipe systems and spaced a few feet apart, at distances ranging from a few inches to as much as 24 ft. from the surfaces being protected. This system is claimed to be effective on all flammable oils and to be suitable for use on electrical fires. It operates at pressures between 45 and 100 lb. per sq. in. Other fog nozzles are available operating at lower pressures. In general, however, these nozzles, whether portable for use on ordinary hose or permanently piped, have not been approved by Factory Mutual Laboratories for use on flammable liquids more hazardous than kerosene. Most types are approved for use on live electrical equipment.

Foam Systems—Permanently installed fire protection systems employing foam are used very extensively, notably in the petroleum industry. Foam is gradually broken down by intense heat and by vigorous agitation and therefore must be applied at a sufficient rate and in sufficient volume to offset these effects. An application rate of ⅔ gal. of foam per sq. ft. per min. is usually adequate if the foam is applied to the surface of the flammable liquid without much agitation. Foam flows readily over open surfaces but does not penetrate well into cracks.

There are four principal methods of producing chemical foam in addition to a new mechanical foam method. In the first method, two foam producing chemical solutions are kept separate in the apparatus until ready for use, when they are mixed and discharged directly or through piping. This type is used for relatively small-scale protection. In the second type the two foam-producing chemicals are contained within the apparatus in dry form, being mixed into the stream of water at the time of discharge. This type is suited to moderate scale protection. The third type, the hopper type generator, is used both in fixed systems and for portable use to supply foam hose streams. The inlet of the generator is connected to a water supply of at least 50 lb. pressure and the outlet to the discharge system or hose. The stream of water in passing through automatically picks up the proper amount of powder from the hopper and foam is produced so long as powder and water are supplied to the unit. This type is used for large-scale protection systems. It is available in two varieties, one using a single foam-producing powder which contains all the necessary ingredients and the other two separate powders. Finally, there is the stored solution system which has now to a considerable extent been supplanted by generator systems. In this system the two foam-producing liquids are stored separately in tanks and pumped at the time of fire by means of a twin or duplex pump through a duplex piping system to a discharge outlet near the point of use where the solutions mix.

Mechanical Foam—A recently developed air-foam system employs a special play pipe and a tank containing a foam-producing solution. The play pipe exerts an aspirating effect on an air inlet and also on a suction pipe leading to the solution tank. As the solution is aspirated slowly into the water stream at the point where air is entrained, foam is produced at the rate of 275–300 gal. per gal. of foam-producing solution, and 12 to 14 gal. per gal. of water. In another air-foam system, air, water and a foam-producing powder are mixed in a power-driven generator operated by a gasoline engine, motor or turbine. This system is said to obtain up to 68 gal. of foam per lb. of powder.

Carbon Dioxide—Two types of permanently piped carbon dioxide protection systems are in use. In the more common type, a number of cylinders holding usually 50 lb. of the gas are connected to the piping system by a manifold. The gas is piped to the point of hazard where it discharges through flaring horns, either into specific hazardous equipment such as covered tanks or kettles, or around the walls of a room which is to be protected by total flooding. Discharge is accomplished by a thermostatic device which opens the discharge control valve after it sounds an alarm.

The second system stores liquid carbon dioxide in large quantities, from 1 to 125 tons, in a vessel which is refrigerated by means of a small self-contained refrigerating unit so that the temperature of the liquefied gas is maintained at about 0 deg. F. and the pressure at about 300 lb. Owing to the lower pressure of the second method, large quantities of liquefied gas may be stored in a single vessel of considerable diameter. Since larger quantities of gas can be stored, a higher release rate is possible. It is also claimed for the second method that the refrigeration of the gas results in the production of a greater proportion of snow to gas upon expansion to atmospheric pressure, thus giving about three times the cooling effect possible with the high pressure storage system. An automatically timed discharge is used. These methods are suitable for the protection of inclosed special hazards such as rooms or tanks containing flammable liquids; and for electrical equipment of all kinds.

Ordinarily it is only necessary to

This portable, wheeled carbon dioxide extinguisher, made by C-O-Two Fire Equipment Co., rapidly controls an electrical equipment fire in a transformer vault

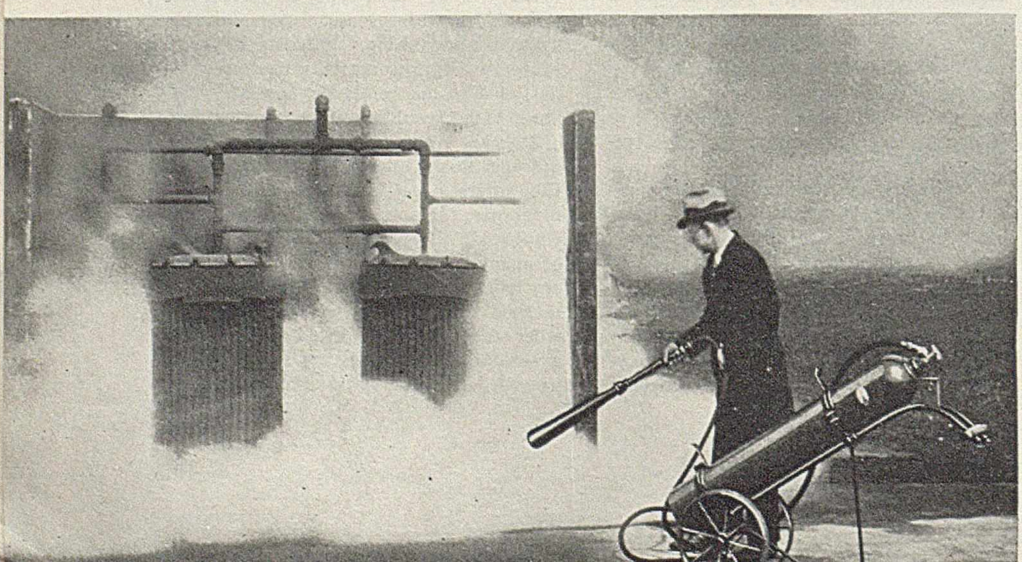


Table II—Sources of Information

In addition to municipal and state authorities who are generally glad to cooperate in matters of fire prevention and protection, there are a number of organizations in the field which are ready and willing to supply extremely valuable information. Some of these organizations issue booklets and pamphlets from time to time and a large amount of this literature is available. Among these organizations may be mentioned the following:

National Fire Protection Association—This organization, located at 60 Batterymarch St., Boston, is an association of national institutes, societies and organizations interested in fire protection, in addition to official and semi-official departments and bureaus, commercial firms, libraries, colleges and individuals. A non-profit organization, the N. F. P. A. develops fire protection standards, issues a quarterly periodical, and publishes a fire protection handbook and numerous bulletins and pamphlets. It holds an annual meeting, maintains a staff of field engineers who work with municipalities and it cooperates with municipal fire authorities and with volunteer fire groups. Publications available from the organization cover every conceivable phase of fire protection.

National Board of Fire Underwriters—This organization, located at 85 John St., New York, is an engineering, statistical and educational organization maintained by the stock fire insurance companies. A staff of trained engineers and investigators suggests fire prevention and protection measures, and cooperates with local authorities. The organization prepares codes and issues public educational material.

Underwriters' Laboratories, Inc.—This non-profit organization, having its main office and test station at 207 East Ohio St., Chicago, was organized primarily for the examination and testing of all manner of devices having a relation to life, fire and casualty hazards. The organization publishes periodical lists of tested and approved products in the fields of electrical equipment, fire protection equipment, etc., gas, oil and miscellaneous appliances, and appliances relating to accident hazard, automotive equipment and burglary protection. Listed products are followed up at frequent intervals. Many special investigations are publicized in bulletins.

Associated Factory Mutual Fire Insurance Cos.—This insurance system, specializing in industrial fire protection, maintains an inspection department and fire protection engineering laboratory at 184 High St., Boston. The organization includes a staff of 125 field engineers, who periodically inspect member properties and advise on hazards and protection. The laboratory carries out original developmental work on fire protection and engages in testing and approving of submitted protection equipment. Numerous publications are issued by the Inspection Department, covering the entire range of industrial fire protection, including pamphlets and bulletins on protective equipment, water supplies, safeguards for special hazards, standards of fire-safe construction, electrical equipment and recommended methods of organizing employees for plant protection.

U. S. Bureau of Standards—The National Bureau of Standards of the Department of Commerce does considerable work bearing on fire protection, especially is the field of fire resistance of materials. It investigates building practices and building codes and develops standards. Publications are issued on fire causes and fire hazards.

U. S. Department of Agriculture—The Bureau of Agricultural Chemistry and Engineering engages in considerable research work and field investigations, particularly on the subject of dust explosions in industrial properties, and on rural fire protection and spontaneous heating and ignition. Pamphlets are available.

National Safety Council—In general, the problem of industrial safety is split between the National Fire Protection Association—which deals with fire hazards and fire protection—and the National Safety Council, 20 North Wacker Drive, Chicago—which deals largely with the accident hazards. However, the National Safety Council has published considerable material on fire prevention, particularly with regard to industrial fires.

Bureau of Explosives—This organization, located at 30 Vesey St., New York, and maintained by the American Railway Association, prepares regulations for the transportation of explosives and other dangerous articles, covering containers, methods of handling and other transportation requirements. The Bureau operates a laboratory to test materials and investigates fires and explosions. It also maintains an inspection service and carries out other activities in the interests of safe transportation.

Literature Sources

"Crosby-Fiske-Forster Handbook of Fire Protection." This handbook, now in its 9th edition, is published at five-year intervals by the National Fire Protection Association. The most thorough and complete collection of fire protection information available, the book covers such subjects as fire losses, fire protection organizations, laws and regulations, common hazards, special industrial hazards, fire retardant and resistant construction, prevention of water damage, water supplies, fire pumps, inside and outside protection, fire extinguishers, inspection and maintenance, private fire organizations, salvage, and other necessary information.

"Industrial Fire Hazards." This book, written by Dana and Milne in 1928 and published by Lakeview Press, Framingham, Mass., is now believed to be out of print and may be difficult to secure. However, if available, it is a valuable study, covering in considerable detail the characteristics, processes and fire hazards of numerous industries and of many chemicals and proprietary compounds.

"Organization and Training of Industrial Fire Brigades." This 120-page booklet, recently prepared by Captain John C. Klinck of the Memphis Fire Department, is available from the publishers, S. C. Toof & Co., P. O. Box 55, Memphis, Tenn., at a regular price of $1 per copy, with quantity discounts for industrial fire brigades. The book necessarily omits any discussion of specialized fire hazards, but describes in detail the tools of the firemen and their proper use, the types of fire protection equipment employed industrially, including such subjects as extinguishers, standpipes, sprinklers and alarms, and goes at considerable length into the organization of the industrial fire brigade, its activities at fires, both normal and those caused by enemy action. Although other literature sources, such as publications of the National Fire Protection Association, deal to some extent with the industrial brigade, so far as is known, this booklet is the most complete treatment of the subject currently available.

"Protection for Industrial Plants." This pamphlet, published by the Office of Civilian Defense, Washington, D. C., will probably be available before this *Chem. & Met.* report reaches its readers. It is stated to deal in considerable detail with the whole problem of industrial fire protection, particularly with respect to the hazards of enemy action.

Periodicals—*Fire Engineering*, monthly periodical circulating largely among professional fire officers, firemen and fire protection engineers, published by Case-Shepperd-Mann Publ. Corp., 24 West 40th St., New York; *Quarterly* of the N. F. P. A., published in Jan., Apr., July and Oct. of each year; *Volunteer Firemen*, published monthly by the N. F. P. A., specifically for volunteers; *Factory Mutual Record*, published monthly by Associated Factory Mutuals, dealing with fires and causes, equipment and apparatus, prevention and protection.

Publications of N. F. P. A.—Lists of publications on hand for distribution are available from this organization. One list covers special published material dealing with war-time fire protection. Another covers all available publications on fires, fire prevention and fire protection. In most cases, a nominal price is charged for these publications when ordered by non-members.

Publications of Associated Factory Mutuals.—Numerous data sheets are published by the inspection department of this organization dealing with specific hazards, construction methods and fire protection methods, in addition to the monthly mentioned above.

reduce the oxygen content of the atmosphere surrounding the fire to about 15 percent although certain special hazards require reduction to as low as about 5 percent.

Fire Alarms—Several methods are in use for the automatic detection of fire so as to sound an alarm or release an extinguishing agent. There are two general types of thermostat used, the fixed temperature type and the rate-of-rise type. The first is used where ambient temperatures are not subject to great change, the latter in applications where solar or process heat might set off a fixed temperature alarm. Fixed temperature thermostats are either assemblies of spot devices located at specified intervals along the ceiling or roof, or of a continuous line type giving the alarm when subjected to a predetermined temperature at any point along the line.

Fixed types are designed to operate at temperatures similar to automatic sprinklers, for example, 135, 165, 212, 286 or 360 deg. F. Some use a fusible or frangible element such as a link or quartz bulb, others a bimetal. One type of rate-of-rise alarm is pneumatic, having an air leak which vents a slow rise in pressure due to temperature increase, but permits a pressure increase in event of a rapid temperature rise, either closing a contact or operating controls through a mechanical bellows arrangement. Another uses two bimetals, one of which is partially protected from the heat source so that on a slow rise they move substantially together, but one moves faster than the other on a rapid rise, so as to close a contact. One type of continuous line alarm uses a special wire with a fusible core. When the core melts, it flows through apertures in an insulating sheath between inner and outer conductors and completes the alarm circuit. The electric eye is also used to some extent for fire and particularly for smoke alarms.

WATER SUPPLY

Public Water Supply—Although many process plants are able to take advantage of public water supply, most such plants will nevertheless require their own water storage to supplement the public supply or to furnish the primary source of water when public supplies are insufficient in volume or pressure or lack dependability. For industrial use, the pressure of the public supply is frequently insufficient, requiring the plant to have fire pumps which may be of centrifugal, rotary or reciprocating construction. In a common arrangement, the pump is installed in a bypass line, between the public main and the plant system. Or the pump suction may be provided with water from a suction tank or reservoir, at or near ground level, to provide a reserve in addition to the public supply.

Reserve Supply—Tanks are used to a large extent to supplement public supplies. Occasionally a private reservoir may be feasible, but ordinarily an elevated tank high enough to provide water to the highest sprinkler or capable of projecting a hose stream at least 40 ft. above the highest building is the best solution. Pressure tanks are sometimes used in congested areas where little storage space is available. When the tank is called upon to supply hose lines from hydrants, a capacity of 30,000 gal., with the bottom not less than 75 ft. above the ground, is usually considered minimum. When the tank is to supply sprinklers, the minimum specified capacity is 5,000 gal. and the bottom of the tank should not be less than 35 ft. above the highest sprinklers. Considerably larger tanks, however, are generally used. When an outside gravity supply tank is chosen, it is necessary to provide means for heating the tank water in winter to avoid the possibility of freezing. The commonest method of accomplishing this is to provide a steam-heated tubular water heater which takes cold water from the base of the standpipe, heats it with steam and induces a thermal circulation upward through a riser having several outlets in the tank proper.

Pressure Tanks—Such tanks should be located above the highest sprinklers they supply, except those at the top story of the building. A tank of 3,000 gal. capacity suffices for light hazards. The tank is kept about two-thirds full of water with air pressure of at least 75 lb. maintained over the water by means of a small air compressor.

PRIVATE FIRE BRIGADES

Many plants have found it expedient to organize private fire brigades. Ordinarily, the brigade is composed of volunteers from various departments of the plant, although in very large plants it sometimes takes the form of a full-time fire department composed of professional fire-fighters. Where processes are of such a special nature as to require extremely specialized fire-fighting knowledge, the private brigade is often in a better position to understand the situation than the public fire department and thus is available to assist and direct the professional department if and when it is necessary to bring the latter to the plant.

Authorities consider that the organization of, and responsibility for, a private fire brigade are directly in the hands of the highest officers of a plant. Furthermore, it is considered necessary that the plant fire department be recognized by the management as an important permanent department if its success is to be assured. The chief of the fire brigade should report to, and be responsible to, the highest executive in the plant organization and members of the brigade should be made to feel that their membership gives them special honor or privilege.

To be effective, a plant fire brigade must be subject to rigid discipline, it must be provided with the apparatus required by the role it is to play, and it must be adequately trained under discipline in actual use of the apparatus. It should have its own constitution and by-laws and hold regular meetings. Its chief should be a man with at least some fire training. In large plants, the heading of the fire brigade should be his sole job. If possible, a man with former fire department experience is desirable. Otherwise, one with mechanical aptitude and training, such as the master mechanic or the maintenance chief, may be a good choice.

The plant fire chief must be given full responsibility, not only for training and drilling of the men, and for the maintenance and testing of the apparatus, but also for the conduct of actual fire fighting. Furthermore, changes in the plant or process should be reviewed and approved by him to the extent that they affect the fire protection scheme of the plant and its fire hazards.

So far as the actual organization is concerned, this will depend to a considerable extent on the size of the plant and the character of its operations. For example, a plant having numerous special hazards will require quite a different type of fire-fighting organization than one in which the bulk of the hazards are of an ordinary nature. Particularly in the plant having numerous special hazards is it desirable to recruit operators from the special-hazard departments who are thoroughly familiar with the character of the hazards, the nature of the equipment, and the location of all valves and pipelines.

Every fire brigade, no matter how small, should have an assistant chief who is able to take over in event of the absence of the chief. Larger brigades having more than one company will also require captains for the several companies. A single company should ordinarily consist of not less than ten men. It is desirable that one company in larger plants should be composed of mechanics having special qualifications including electricians, steam and pipe fitters, cutting torch operators and maintenance men.

In so far as possible, every member of the plant brigade should be made familiar with all special hazards of the plant, with the extinguishment peculiarities of certain processes, principally those where water should not be used, and with the location of all hydrant houses, chemical engines, hose carts, standpipes, sprinkler valves and first aid fire extinguishers.

Many books and bulletins are available to assist in training the brigade, some of which are noted in Table II on page 103. Drills should be held at least twice a month, generally on company time. These drills should make use of the regular fire-fighting equipment and should familiarize the men with all conditions and parts of the plant and enable them to deal with any emergency which may arise.

Cooperation with the municipal fire department is obviously of great importance. Many plants make a regular practice of inviting the local companies to the plant at regular intervals, to inspect the property and familiarize themselves with the arrangement of buildings and with special hazards. This is particularly desirable in the case of those plants where the requirement of specialized extinguishment methods makes it necessary for the municipal company to operate only under the direction of the plant chief.

One important factor in cooperating with the municipal fire department is to make certain at all times that apparatus can get through the plant gates and to the scene of a plant fire with the least possible delay. Roads should be maintained clear and watchmen should be instructed to leave yard gates open in case of fire and be ready to direct fire apparatus to the point of trouble. When a plant has railroad tracks, it is important that cars should not be left so as to block important crossings.

ACKNOWLEDGMENTS

Chem. & Met. particularly wishes to acknowledge the valuable assistance of the National Fire Protection Association, and of the Inspection Department of the Associated Factory Mutual Fire Insurance Cos., whose publications and instructive suggestions and advice were made available to the editors. In addition, assistance was rendered by manufacturers of fire protection equipment including American-LaFrance-Foamite Corp., Elmira, N. Y.; Buffalo Fire Appliance Corp., Buffalo, N. Y.; Cardox Corp., Chicago, Ill.; C-O-Two Fire Equipment Co., Newark, N. J.; Globe Automatic Sprinkler Co., Philadelphia, Pa.; B. F. Goodrich Co., Akron, Ohio; Grinnell Co., Providence, R. I.; Walter Kidde & Co., New York, N. Y.; National Foam System, Inc., Philadelphia, Pa.; Pyrene Mfg. Co., Newark, N. J.; and Safety Fire Extinguisher Co., New York, N. Y.

Much published information has been used freely by the editors, largely without specific acknowledgment. General acknowledgment for this material is hereby made, particularly to the organizations and companies mentioned above and to the authors and publishers of several of the books referred to.

Machinery, Materials and Products

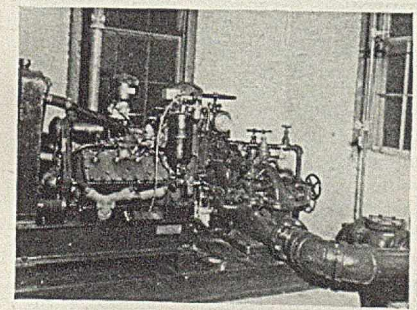
CHEM & MET PROCESS EQUIPMENT NEWS

Fire Protection Pumps

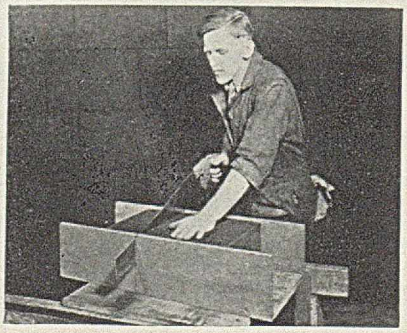
To PROVIDE moderate-cost fire protection for small plants, Fairbanks, Morse & Co., 600 South Michigan Ave., Chicago, Ill., has developed a new Underwriters Laboratories approved fire pumping unit, consisting of one of this company's 4-in. centrifugal fire pumps, driven by a Ford-Mercury engine. The Mercury engine drive, turning at 2,500 r.p.m., is of sufficient speed to be direct connected, thus eliminating the need for gear drive, simplifying the installation and materially reducing installation and maintenance costs. An incidental advantage is that the engine can readily be serviced at any point in the country.

This company has also announced a new portable pumping unit available in a number of types, of which a typical example consists of a 2-in. nonclogging sludge pump, direct-connected to a 3-hp. splashproof motor mounted on a standard warehouse truck with 8-in. rubber-tired wheels. A small hand-operated bracket-type pump mounted on the truck platform, with its suction connected to the top of the centrifugal volute, is provided for priming. The particular unit mentioned has a length of 2½ in. wire-lined rubber suction hose and a length of 2½ in. collapsible cotton fabric discharge hose. Such units are suitable not only for various kinds of emergency service, but also for regular service in transferring materials between tanks.

Mercury-engine-driven fire pump



Sawing new Foamglas insulation



Cellular Glass Insulation

GLASS in a new form, never before manufactured, appears in the new cellular glass insulation material for use in cold rooms which has been introduced by Armstrong Cork Co., Lancaster, Pa., under the name of Foamglas. The new material is said to offer permanent insulating efficiency in numerous low-temperature applications. Its cellular structure results in the formation of a slight vacuum within the cells which is claimed to provide a highly efficient barrier to heat passage. Furthermore, the material is said to be positively proof against internal condensation and the passage of water vapor. It is fireproof and waterproof, it has sufficient structural strength to support an insulated ceiling and can be readily sawed and worked with ordinary tools.

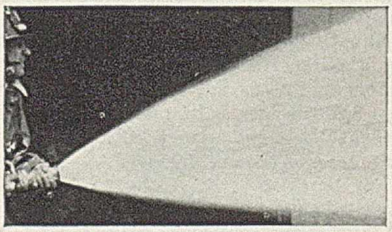
This material is made by firing ordinary glass which has been mixed with a small quantity of pure carbon. At the proper temperature the glass softens and the gas formed produces a cellular product which cools in hard, vitreous slabs. The material was developed and is made by Pittsburgh-Corning Corp., but is marketed exclusively in the low-temperature field by Armstrong Cork Co. Standard 12x18-in. blocks are available in various thicknesses from 2 to 6 in.

Spray Fire Nozzle

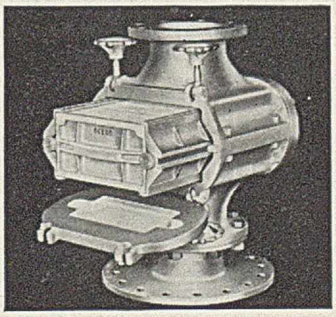
A NEW water-spray nozzle, known as the Alfcospray nozzle, has been developed by American-LaFrance-Foamite Corp., Elmira, N. Y., to meet demands for a variable, all-spray nozzle which cannot produce a straight stream. From the shut-off position a slight turn of the tip immediately gives a cone spray of 40 deg. Further slight rotation produces increasing cones up to a full curtain of 150 deg. The advantage of the nozzle is that it is impossible to produce a solid water stream inadvertently which might be applied to a live electric circuit. The varying cones are also said to be excellent for extinguishment of heavy oil fires and for general cooling purposes. This nozzle, known as Model 10F, is available for several hose sizes including 2½ in. In the 40-deg. spray position its capacity is about 95 g.p.m. at 50 lb. water pressure.

In its full curtain position, the new nozzle is said to provide an effective water screen to protect men and property. Furthermore, it is claimed to be more effective on Class A fires than a straight-bore nozzle.

Alfcospray nozzle set at 40 deg.



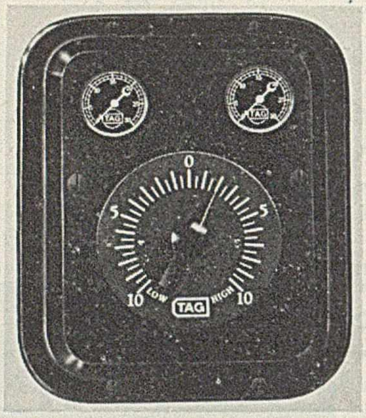
Flame arrester for tanks



Flame Arrester

To PROTECT tanks containing volatile, flammable liquids against fire hazards, the Johnston & Jennings Co., 877 Addison Road, Cleveland, Ohio, has announced the Oceco flame arrester which permits free passage of vapors, but offers a positive stop against flame entering the tank if the vapors should become ignited. This flame arrester is also employed to prevent the propagation of flame or explosion through pipe lines carrying explosive gases. The unit consists of a strong, rigid housing with a cover, containing an all-aluminum flame arrester element. The housing of cast semi-steel can withstand direct exposure to heat and flame. The arrester element consists of alternate flat and corrugated sheets of aluminum, arranged to present vertical straight-through passages to the flow of gas or vapor and minimize pressure drop, as well as any tendency to retain moisture and foreign materials. A net free area of the arrester element twice that of the pipe is provided. Available sizes range from 2 to 10 in. Units carry Underwriters Laboratories approval.

Among the claims made by the manu-



No. 42 controller

facturer is the statement that in numerous test installations of this equipment, no tight tank so equipped has ever been lost by fire, even when located in the middle of a blazing tank farm.

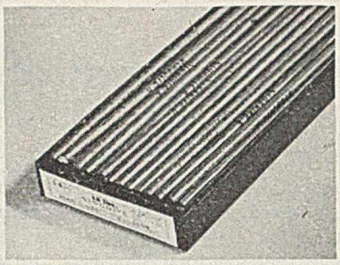
Non-Indicating Controller

SMALL SIZE, simple construction and accuracy of operation are claimed for a new non-indicating controller known as Tag No. 42 which has recently been placed on the market by C. J. Tagliabue Mfg. Co., Park and Nostrand Aves., Brooklyn, N. Y. The instrument is claimed to be suited to the majority of automatic control applications and employs thoroughly tested elements redesigned for compactness and simplicity. It is adapted to both temperature and pressure control in a number of convenient ranges.

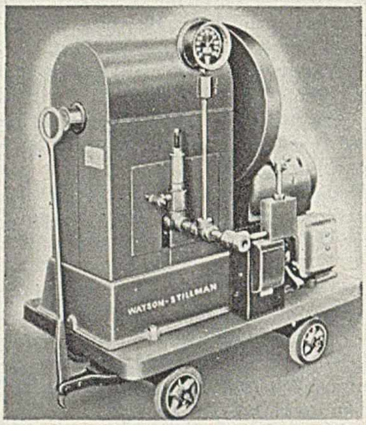
The company has also announced a new line of self-operating temperature controllers suitable for such applications as hot water storage heaters and tanks. The controller is of the type deriving its power from changes in the vapor pressure of a volatile liquid in the tube system. Sensitivity is achieved through the use of a small diameter valve stem equipped with a lubricator.

Hard-Facing Rods

TO SUPPLY concerns unable to furnish high priority ratings, the Stoody Co., Whittier, Calif., has developed two new hard-facing-alloy welding rods which are being marketed under the trade names of Stoodite K and Stoody Self-Hardening K. The first rod produces deposits having an average hardness on the Rockwell C scale of 54-58, and is said to yield smooth dense deposits free from porosity and shrinkage cracks. This rod is recommended for hard-facing such equipment as cement mill parts and brick and clay equipment. The second rod is slightly less hard and is particularly adaptable to deposits on manganese steel. Deposits can be forged at a red heat. Applications for this rod include roll, jaw and gyratory crushers, and bucket



New hard-facing rod



High pressure test pump

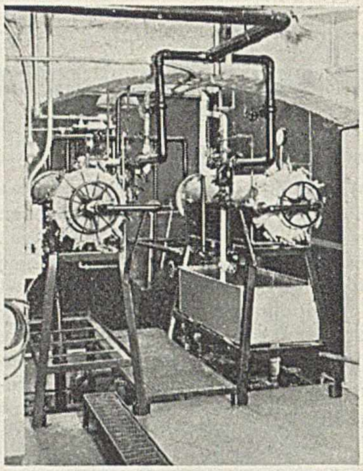
conveyors. Both types are available for either alternating or direct current welding. Both can be had under regular A-10, P-100 ratings. Further information can be obtained from Air Reduction Sales Co., 60 East 42d St., New York, N. Y.

Portable Test Pump

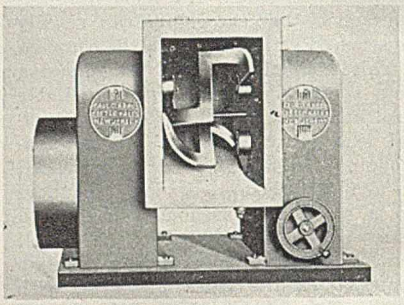
RAPID TESTING of pressure vessels, piping systems and boilers is the function of a new motor-driven portable test pump which is now being manufactured by the Watson-Stillman Co., Roselle, N. J. The unit is inclosed and is mounted, together with its motor, on a hand truck for portability. The pump is of the three-plunger vertical type with ½-in. diameter plungers having a 2-in. stroke. Driven by a 3-hp. motor at 100 r.p.m., the pump develops 8,200 lb. per sq.in. maximum pressure at ½ g.p.m. capacity. All necessary accessories are included.

Closed-Type Filters

AN ACCOMPANYING VIEW illustrates an improved type of filter developed by LeVal Filter Co., 1319 South Michigan Ave., Chicago, Ill., for applications requiring closed system filters which can be cleaned without opening or dismantling, especially in locations needing explosion-proof electrical equipment, or where hazardous liquids and acids are to be handled. The units shown employ patented filterstones made in the shape of a hollow disk which in use are coated with a filter aid. The stones are supported in the center of the cylindrical tank and are



Closed-type filters



Improved double-arm mixer

revolved as they are backwashed and sprayed at the conclusion of the run. Initial tests for flow rates on an installation of this type, handling a water-thin highly corrosive product, gave 333 g.p.h. per sq.ft. of filter area for a pressure drop of 18 lb. across the stones. The units illustrated each contain 20 sq.ft. of filter area.

Improved Mixers

IMPROVED DESIGN, streamlined appearance and complete inclosure of the gears and stuffing box are featured in the redesigned line of Cincinnatus and Mastodon double-arm mixers recently announced by Paul O. Abbé, Inc., 375 Center Ave., Little Falls, N. J. The Mastodon heavy-duty-construction mixers are built in sizes from 3 to 150 gal. capacity, and the Cincinnatus lighter-construction mixers in sizes to 300 gal. The complete inclosure of the new mills reduces required operating space and assists in keeping the machines clean. The company's overlapping design of mixing blades is said to insure fast and efficient mixing action.

Burglar Alarm Control

FOR PROTECTION against intruders and saboteurs seeking to gain entrance to industrial plants, a new long-range photoelectric burglar alarm control has been developed and made available by Photoswitch, Inc., 21 Chestnut St., Cambridge, Mass. The new Type A28-L control is suitable for both outdoor and indoor applications over very long ranges, employing a light source capable of projecting a practically invisible beam of light for distances of 350 to 700 ft. Thus, it is possible completely to surround the plant with several of these units. If the light beam is broken by an intruder, the photoelectric control contacts close thereby sounding an alarm, turning on floodlights, closing gates or performing other similar functions. The control is provided with a latching unit which latches the alarm in operation once the light beam has been momentarily broken, until a reset button is operated.

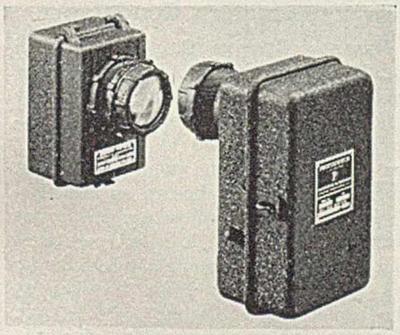
Changes in local light have no effect on the control which is designed for operation 24 hours a day.

Wooden Sash

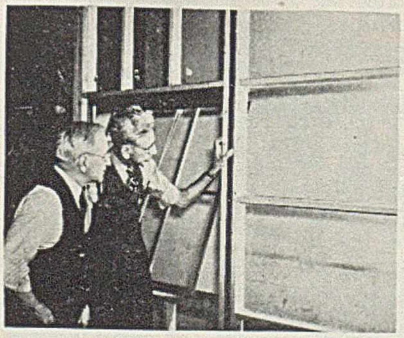
Of interest to all industrial plants contemplating new construction is the wooden, steel-saving "Victory Sash," recently developed and made available to industry by the firm of Albert Kahn Associated Architects and Engineers, Inc., New Center Bldg., Detroit, Mich. The organization has waived patent rights in order that the design may be available to all and will be glad to supply blueprints in detail to anyone interested.

The new development is said to be capable of serving industrial and other buildings quite as well as standard steel sash. Nevertheless, only a small amount of steel is required. Experience gained in the development of steel sash was called upon and the most of frame members common to old-fashioned wood sash were eliminated. Units are built complete in the mill and shipped to the job for erection, similar to steel sash. As units are erected, the mullions are joined by a coverplate of light, pressed metal with a small intervening space allowed for expansion and contraction. Caulking compound furnishes complete waterproofing. At the sills the wood sash is secured by metal clips clamped only at the mullions with regular mullion bolts. The design facilitates glazing and minimizes deterioration of the wood. Owing to probable difficulties with ventilator sections employing wooden framing, the new design calls for steel ventilators which, however, require only a small amount of steel compared with the amount of fixed wooden sash in a building. The design makes extreme height possible in single units, and thus means considerable saving in horizontal supporting members, while allowing maximum light for the amount of material used.

Photoelectric intruder detector



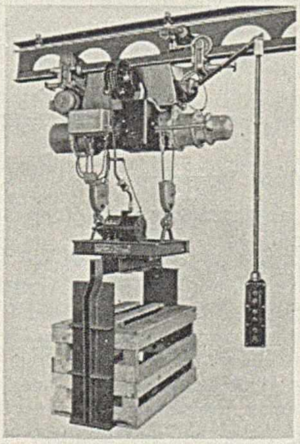
Albert Kahn and John Schurman, designer of the "Victory Sash," examine section of this new steel-saving factory window.



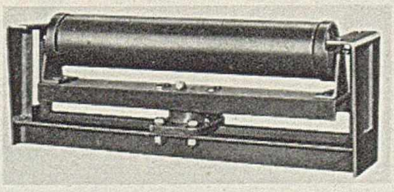
Box Grab-Carrier

A motor-driven grab and carrier, designed especially for handling crates and boxes in and out of storage, or from one elevation to another, is one of the most recent developments of Cleveland Tramrail Division, the Cleveland Crane & Engineering Co., Wickliffe, Ohio. The unit enables quick stacking or removal of crates at a great height with safety. It is completely motorized, with all operations conveniently controlled by six buttons. If desired, the unit can be provided with an operator's cab in which all controls are located. As appears from the accompanying illustration, the arms of the grab are extended and retracted by motor-driven geared slide bars mounted on top of the grab. A double-hook cable-type electric hoist elevates and lowers the grab with a minimum of swing. A quick-acting electric brake stops and holds the load wherever desired.

Motor-driven box grab



Self-aligning idler



Belt Aligner

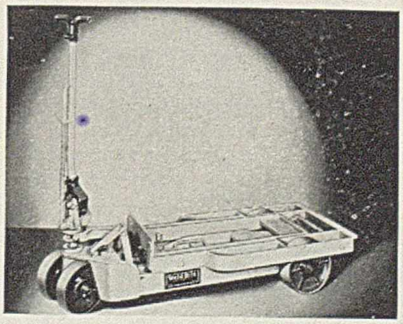
To insure the longest possible life of conveyor belts, Chain Belt Co., 1600 West Bruce St., Milwaukee, Wis., has announced a new self-aligning idler for flat conveyor belts, for use on both the return and carrying runs. The idler is designed to assist in keeping the belt central on its supporting idlers, thus avoiding edge wear. The operation of the new idler is said to be sensitive and instantaneous. If for any reason the conveyor belt runs to one side, it has a tendency to swivel the idler in a horizontal plane. If this in itself is not sufficient to cause the idler to swing enough to force the belt to throw back immediately, the belt will continue traveling to one side until it contacts a counterweighted end disk which is slightly larger in diameter than the idler roll. Contact with this disk tends to rotate it, but since it is counterweighted, it resists the tendency to rotate and produces a counter force on the idler, causing the latter to swivel rapidly and throwing the idler more out of line so as to force the belt to swing the other way immediately.

Where excessive misalignment of a conveyor belt exists, caused by such factors as stretch or weave in the belt, uneven loading of material on the belt, or shifting of the conveyor frame, several of these self-aligning idlers spaced at intervals between the stationary idlers are stated automatically to bring the belt back to central position and avoid the possibility of serious injury.

Heavy-Duty Lift Truck

To fill out the company's present line of Weld-Built lift trucks, the West Bend Equipment Corp., West Bend, Wis., has announced development of a new 10,000 lb. capacity hydraulic lift truck designated as Model L. This

5-ton lift truck



model has all standard features common to other trucks of this company's line, including the company's shock-proof, horizontally mounted hydraulic lift unit. Available in both narrow and wide platform types, it employs parts capable of handling much heavier loads than the specified rating. Moving parts are all supplied with ball or roller bearings for easy handling.

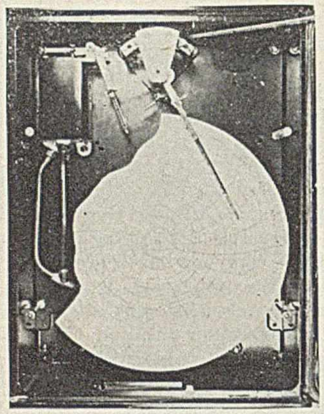
Equipment Briefs

A POWDER known as Magout, developed by Pulmosan Safety Equipment Corp., 168 Johnson St., Brooklyn, N. Y., has been announced for the extinguishment of magnesium fires. It is claimed to be equally suitable for both magnesium shavings and magnesium incendiary bombs. The material is non-absorbent, does not deteriorate and can therefore be kept on hand either in bulk quantities, or in cardboard containers of a new type.

AN IMPROVED plastic pump in which the step-valve, inlet and discharge connections are made entirely from transparent plastics is being offered by Milton Roy Pumps, 1300 E. Mermaid Ave., Philadelphia, Pa. The pump is recommended for handling alum solutions, hypochlorites, weak acids, mineral and animal oils, since the "Plexiglas" valve is unaffected by most inorganic solutions and by alkalis and oxidizing acids only in high concentrations. The pump has double-ball ground glass checks and adjustable stroke for accurate control of volume from one quart per hour up to maximum capacity of 100 gal. per hr. for the Duplex models and 50 gal. per hr. for the Simplex models against pressures up to 150 lb. per sq. in.

FOR BLACKOUT alarms, Photoswitch, Inc., 21 Chestnut St., Cambridge, Mass., has developed the Photoswitch Photoelectric Blackout Alarm control. This control is placed in a convenient location so that it views a centrally controlled street lamp. Through the Photoswitch are connected alarm systems operating inside the factory and when the street lights are turned out, the control observes this and the alarm is sounded. The unit is designed to operate independent of a momentary flickering of the street lamp. It will provide an alarm system for factories and plants in which noise from the din of machinery, etc., makes it difficult to hear an external air raid warning siren.

BLACKMER PUMP Co., Grand Rapids, Mich., has announced a combination rotary-centrifugal dual pumping unit, comprising a cast bedplate on which is mounted a 4-hp. motor with a gearhead on one end to drive the rotary pumping unit, and a shaft extension on the other end, direct-connected to a centrifugal pump. The capacity of the first mentioned pump is 44 g.p.m. at 50 lb. per sq.in. (on a liquid such



New absolute pressure recorder

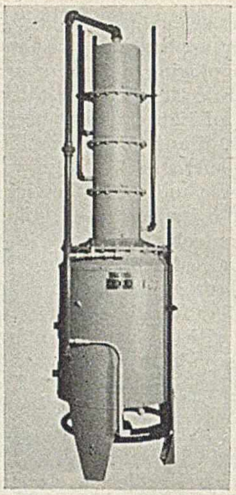
as oil), while that of the centrifugal pump is 75 g.p.m. at 25 lb. per sq. in. (on a liquid such as water). The unit is employed for applications in industrial plants where two dissimilar liquids must be handled together.

TO ASSIST research workers and others seeking instruments required in their work, but difficult to find, the National Research Council has recently appointed a committee on the location of new and rare instruments, of which D. H. Killeffer is chairman. Those needing the services of the committee should communicate with Mr. Killeffer at 60 East 42d St., New York, N. Y. On the other hand, the committee desires assistance from the owners and builders of instruments falling within the new and rare classifications, which might be made available to others through sale or for temporary use.

THE LINE of electric furnaces manufactured by H. O. Swoboda, Inc., 13th St., New Brighton, Pa., has recently been augmented by a new full-muffle electric box-type furnace with an all-refractory hearth, designed primarily for ceramic use at temperatures up to 2,000 deg. F. A new center-pivoted door decidedly simplifies construction. Chamber dimensions are 3¾x5¼x12 in.

Absolute Pressure Gage

FOR THE MEASUREMENT of pressures which are low enough to be seriously affected by variations in atmospheric pressure, Brown Instrument Co., Philadelphia, Pa., has developed and announced a new absolute pressure gage, said to have exceptionally high accuracy of calibration and a long life. In common with other instruments of the type, the gage measurement is the sum of the existing atmospheric pressure and the pressure of the measured substance above or below that of the atmosphere. The actuating elements consist of a spring and bellows assembly, including an upper evacuated bellows (sealed at nearly perfect vacuum) which contains a calibrating spring, and a lower actuating bellows connected to the source of measured pres-



Niagara "No-Frost" concentrator

sure. The top of the evacuated bellows and the bottom of the actuating bellows are fixed while the adjacent ends of the two bellows are attached through suitable linkages to the recording pen.

The action of the actuating bellows is the same as that of any ordinary bellows-actuated gage. However, the evacuated bellows expands or contracts with changes in atmospheric pressure and thus adds or subtracts a correction by producing a force equal but opposite to the varying atmospheric force on the actuating bellows. The instrument is available at present only as a single-record recorder or single-record air-operated controller. Ranges now available include 100, 200, 300, 400 and 500 in. of mercury absolute, and 15 lb. per sq.in. absolute.

Low Temperature Conditioner

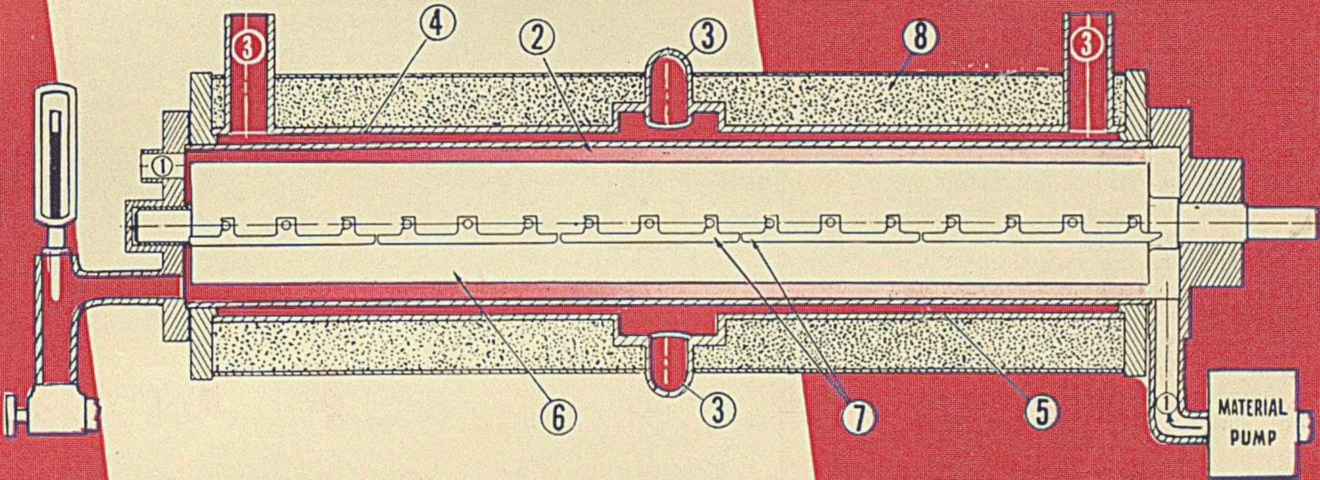
NIAGARA BLOWER Co., 6 East 45th St., New York, N. Y., has announced availability of equipment for the air conditioning of cold rooms at temperatures as low as —50 to —80 deg. F., for use in processing and experimental work. The process, known as the "No-Frost" method, provides equipment for maintaining these low temperatures and also for introducing fresh make-up air without ice or frost forming on the cooler coils. Owing to this fact, the new equipment is said to give constant operation without interruption or loss of capacity. It employs this company's "No-Frost" liquid which is stated not to be a brine and not to be corrosive. The process employs coolers operated in stages, the first stage reducing the temperature to just above the freezing point of water and removing moisture condensing at this temperature. The second stage, employing the "No-Frost" liquid to remove the balance of the moisture, is made continuous by use of a concentrator for the liquid, as shown in the accompanying illustration. The third stage produces and holds the required final temperature.

CUT HEAT TRANSFER TIME TO SECONDS WITH VOTATOR!

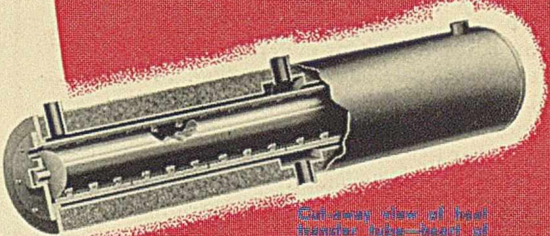
Speed is essential in producing these vital war materials . . .

SYNTHETIC RUBBER
OIL PRODUCTS
CHEMICALS
PLASTICS

KEY TO VOTATOR FLOW DIAGRAM—1. Product connections. 2. Annular space thru which product passes. 3. Heat transfer medium. 4. Heat transfer medium passes thru this annular space. 5. Heat transfer tube. 6. Mutator shaft. 7. Scraper blades. 8. Insulation.



VOTATOR PERMITS HEATING OR COOLING LIQUIDS AND VISCOUS MATERIALS INSTANTANEOUSLY WITH EXTREMELY ACCURATE TEMPERATURE CONTROL!



Cut-away view of heat transfer tube—heart of the Votator.

- If the heating or cooling of liquids or viscous materials is slowing down your war production, then the remarkable Votator heat transfer unit will help solve your problems!

With the Votator a continuous flow of product passes through the unit, and heat transfer is accomplished IN SECONDS! There is absolute uniformity of product because accurate temperature control is maintained at all times. Danger from contamination is eliminated—the Votator is constructed of stainless steel and is fully enclosed. Votator also offers the time and cost cutting advantages of mixing, emulsifying or aerating simultaneously with heating or cooling, if desired.

IMPORTANT!

Increase your war production output tremendously by switching from slow, batch production methods to rapid, continuous Votator method. Votator units are quickly and easily installed in virtually existing systems.

OUTSTANDING FEATURES OF THE VOTATOR!

- HEAT TRANSFER TAKES PLACE IN SECONDS.
- CONTINUOUS, RAPID FLOW OF PRODUCT.
- FULLY CLOSED SYSTEM.
- UNIFORM TEMPERATURE ACCURATELY CONTROLLED.
- SIMULTANEOUS MIXING, EMULSIFYING OR AERATING.
- MORE ECONOMICAL.

Send now for free descriptive book.

The VOTATOR
A highly efficient, continuous heat transfer unit

THE GIRDLER CORPORATION
VOTATOR DIVISION • LOUISVILLE, KY.

The Mining and Refining of Diatomite

THE deposit of diatomite near Lompoc, Calif., supplies raw materials for filter aids, fillers and insulations. Where the Santa Ynez Range terminates in the hilly Point Conception region, lies one of America's most unique mineral deposits. It is a great bed of folded and stratified diatomite, the total thickness of which is 1,400 ft., and the area about 4,000 acres. This was first laid down several million years ago. It is formed of fossil diatoms, which are little microscopic plants having the capacity to form shells of nearly pure opaline silica. The individual particles of extreme fineness are of extraordinary structure and complex ornamentation.

At the Lompoc operations of Johns-Manville there are a well-integrated series of processes which cover the mining of the crude diatomite, transportation, preliminary drying, milling, classifying, and processing of powder products, the making of aggregates, the fabrication of insulating bricks, etc.

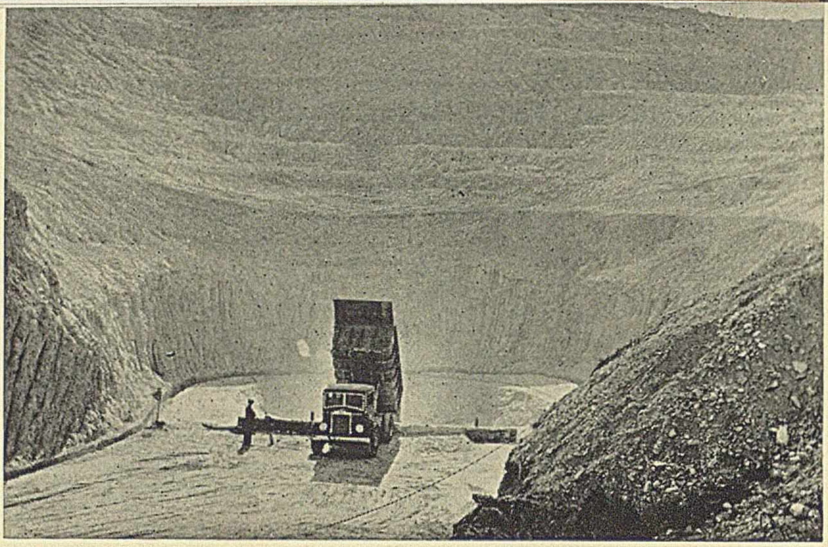
Operations are carried out simultaneously in a series of fully developed and selected quarries, making available a variety of raw materials for different products and for blending. Primary milling and blending of the wet crudes are carried out at a centralized plant located underground in solid diatomite. The distribution of crudes to the separate milling and processing units is by conveyor belts to storage and feeder bins. The accompanying drawing is a simplified flowsheet of operations beyond this point for one of four separate units. The pictures illustrate some of the essential operations in the process.

The crude, after preliminary crushing, is dried, milled, purified and classified simultaneously by a series of treatments with pneumatic blowers, separators and classifiers. Uncalcined, calcined and flux-calcined powders are produced in a number of particle size ranges. Calcination is carried out principally in rotary kilns. Subsequent steps are dispersing, conveying, seperating, classifying and packing. Much of the equipment is of special design adapted for diatomaceous silica.

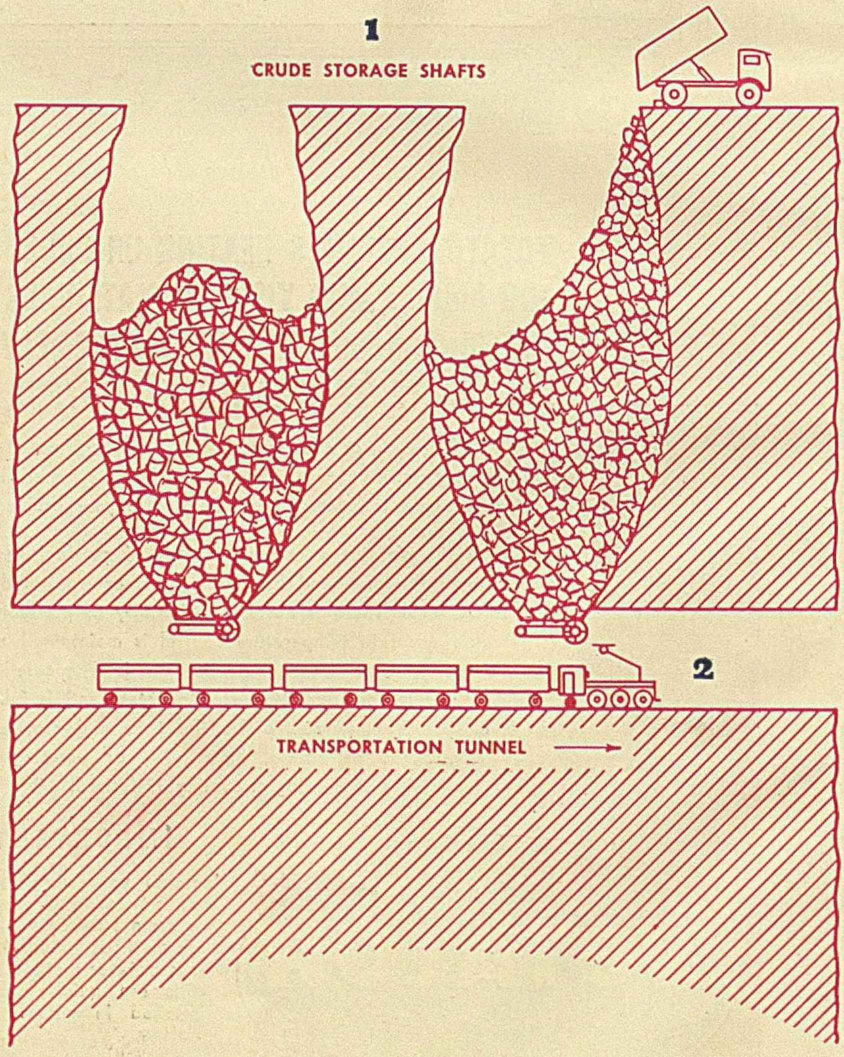
CHEMICAL & METALLURGICAL ENGINEERING

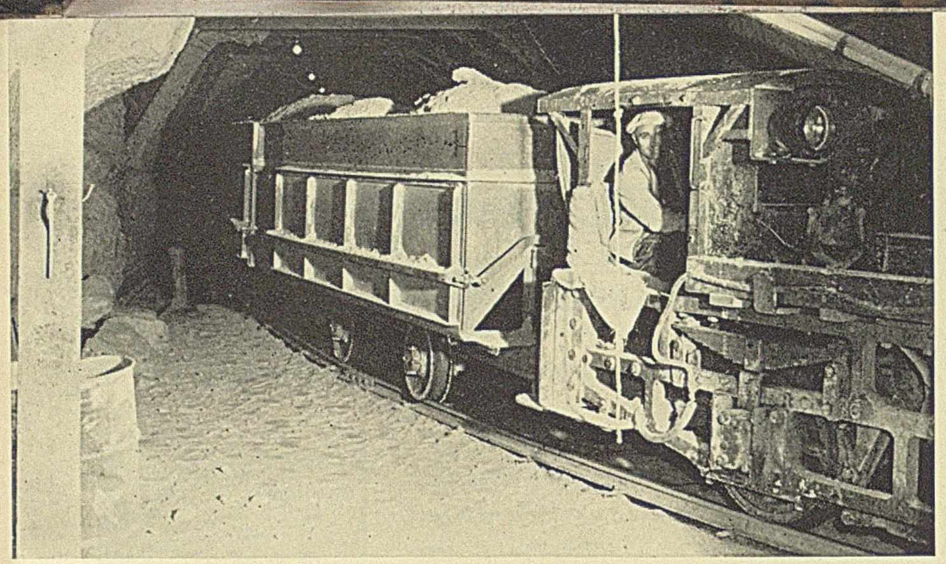
August, 1942

PAGES 110-8 to 113-8

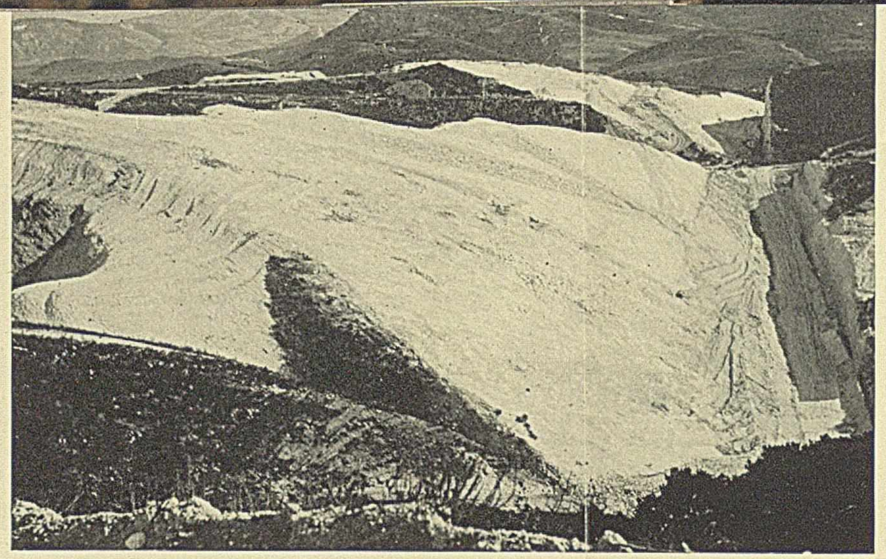


1 Crude diatomite unloaded into storage shaft for later delivery to mills. Some of these hold several thousand tons of material. Shaft is in solid diatomite

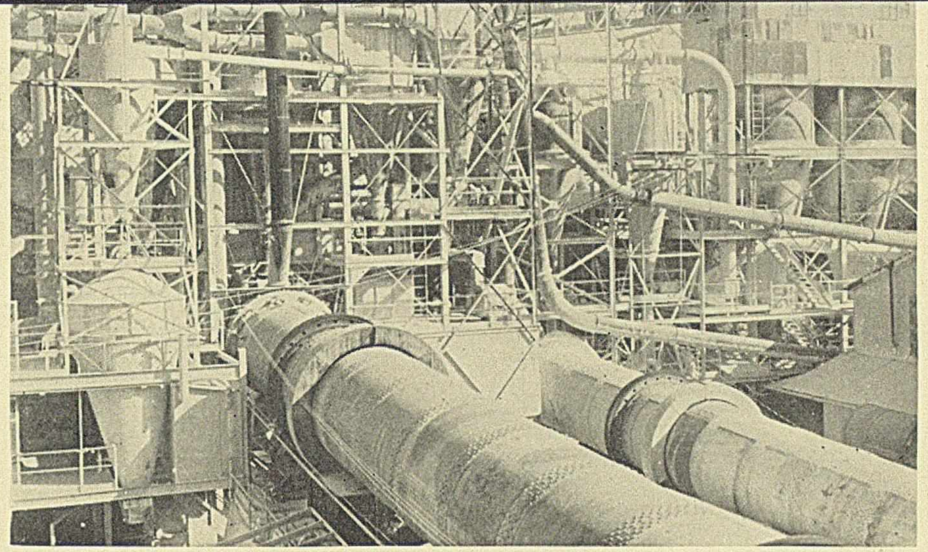




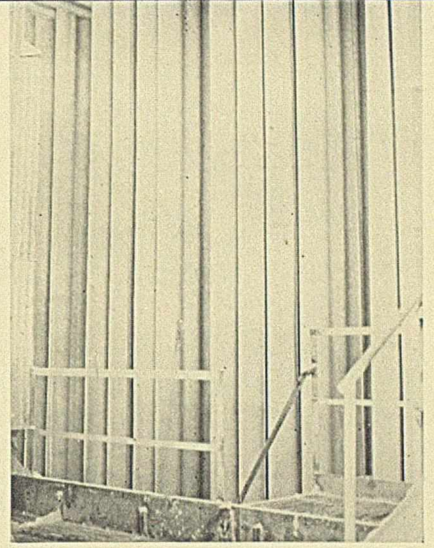
2 Transportation of raw material from storage areas to the mill sites is by underground electrified trains operating in tunnels at mill elevation



3 Two of the large open cut quarries in mountains of diatomite. These are operated by drag line or power shovels and trucks. General topography is shown



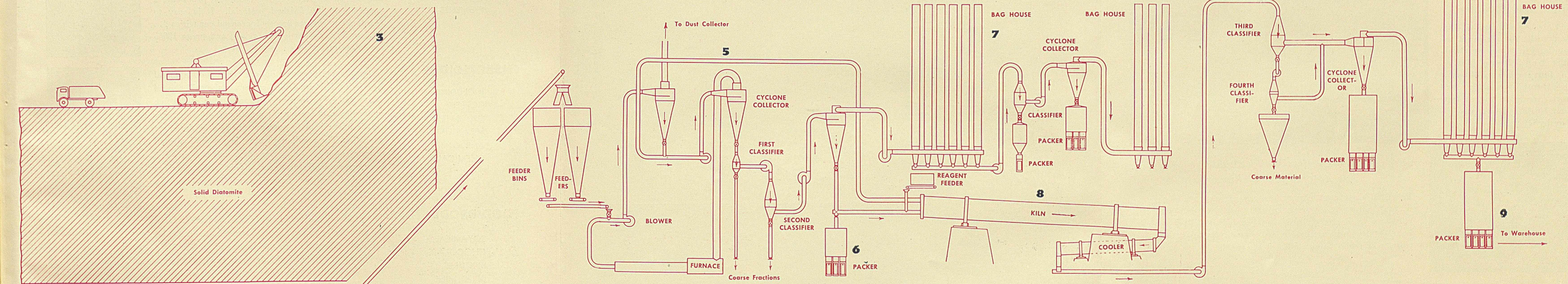
5 A portion of the filter aid mills, showing drying, milling, classifying and separating equipment. A large cliff of diatomite appears in the background

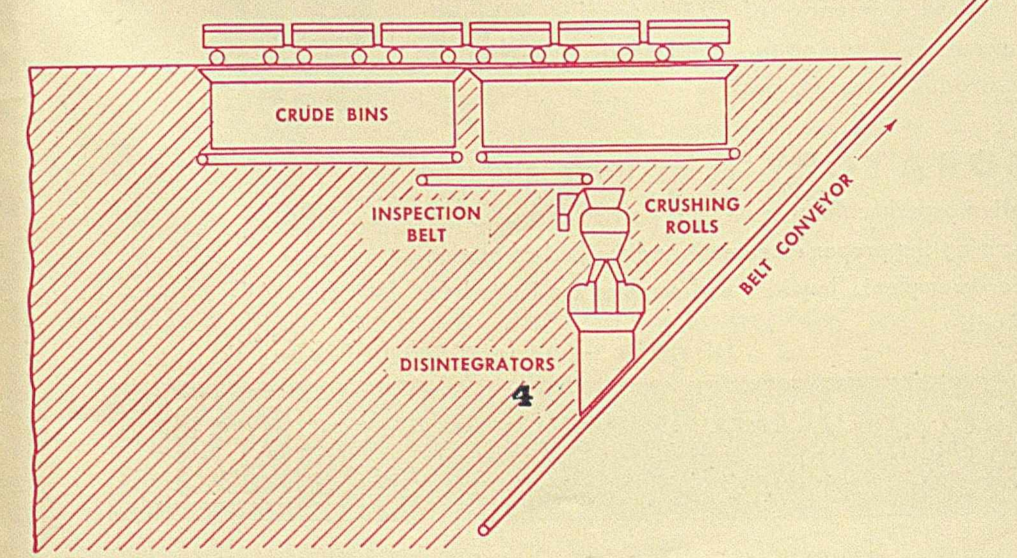


7 Stocking dust collectors aid in classification of diatomaceous powders

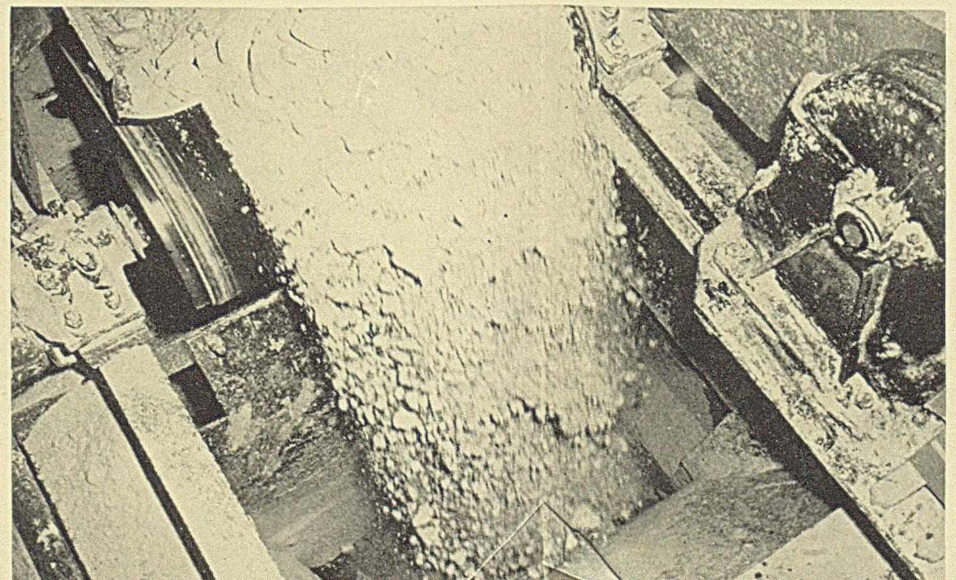
9 Warehousing showing lift truck and pallet methods. Products packed in 50 lb. paper bags for shipment

A Chem & Met FLOW SHEET

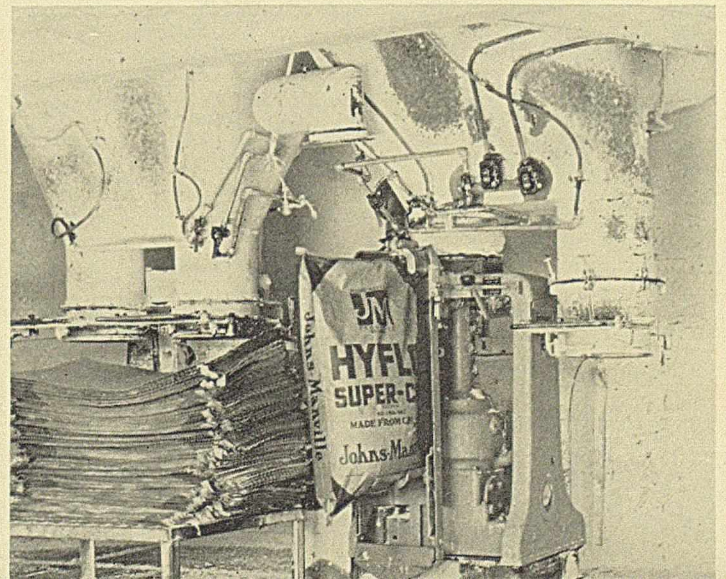




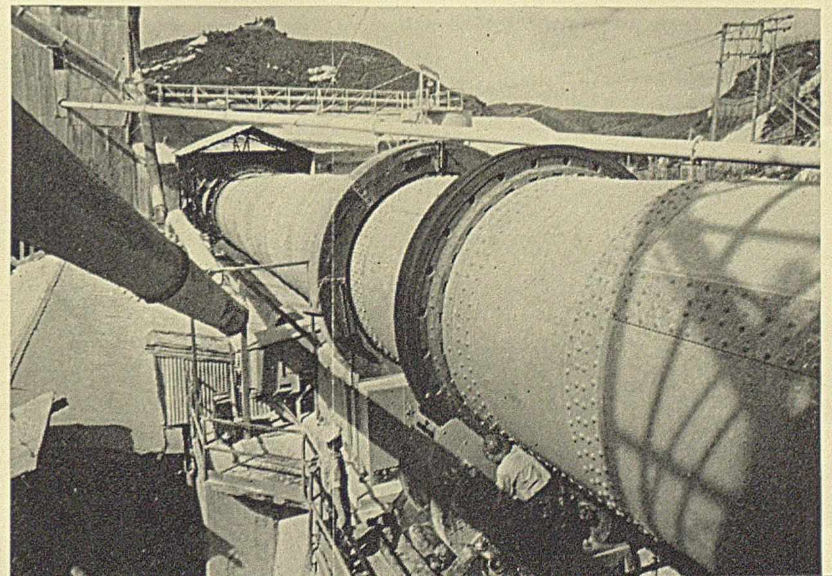
4 Start of primary crushing and grinding. Wet crude is discharged from a belt into a spike roll, and then to hammer mills for distribution to secondary milling and processing units

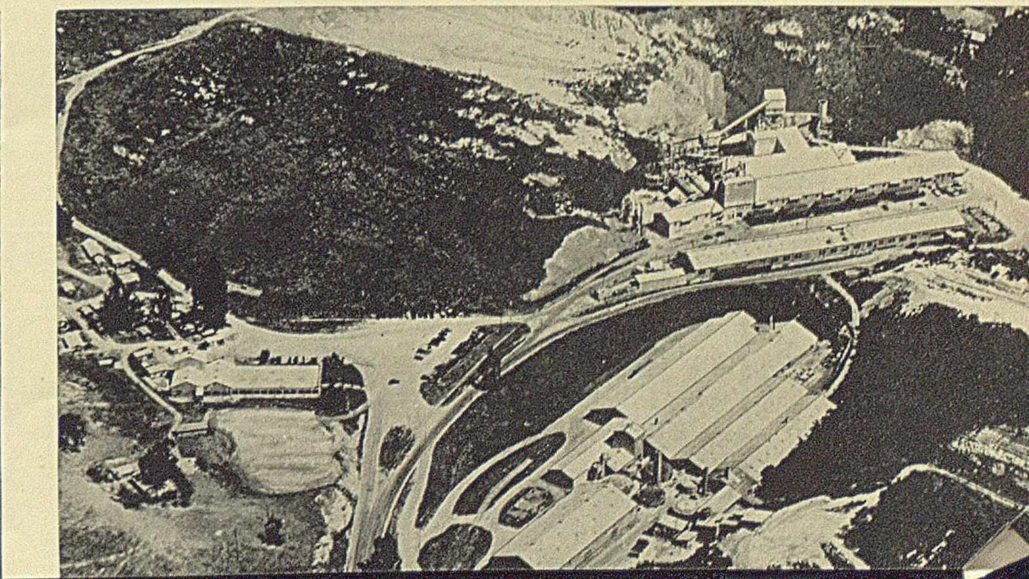


6 Mechanical packers operating directly from packing bins are employed for the packaging of finished products



8 One of the rotary calciners, gas or oil fired, looking from feed end of kiln. Powdered and processed diatomite is heat treated in units of this type

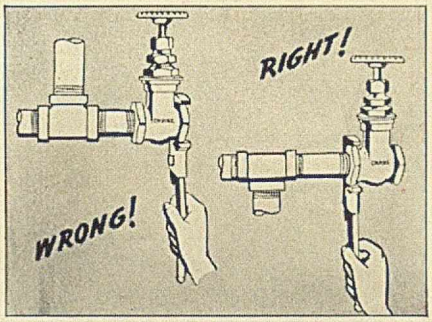




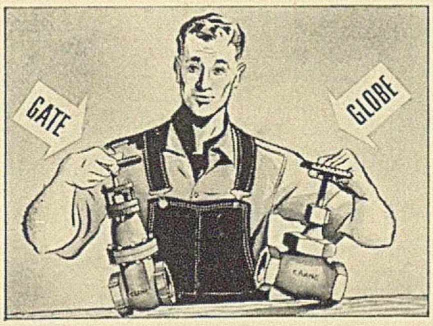
Entire operations are based in heart of diatomite deposits. Sil-O-Cel insulating brick plant in foreground. Filter aid and filter mills in background

You and they have two big jobs—(1) meeting the gigantic demands of war production, (2) keeping your plant in shape to meet those demands. That means proper maintenance—with a capital "M"! Long before Pearl Harbor, Crane Co. saw this need, and inaugurated "Piping Pointers"—to help you and them do the job. Today, these Crane bulletins on better installation and care of piping are training new workers and spreading the gospel of proper maintenance—for peak production, for conservation of critical materials—for Victory! These examples show how they're doing it.

HELP FOR FIGHTERS ON THE *Home Front*



TREAT PIPING RIGHT is rule No. 1 in making present valves and fittings last longer—give maximum service. In "Piping Pointers," Crane tells maintenance men exactly how to do it—how to avoid little careless habits that shorten the life of equipment—how to prevent replacements now when replacements are harder to get.



PICKING THE RIGHT VALVES for specific services is a sure way to eliminate interruptions and delays in production lines. "Piping Pointers" give clear directions on valve selection. Workers using this service know when, where, and why to install gate valves—when to choose globe, angle or check valves.

FOR TRAINEES OR VETERANS—Men who never handled a wrench before quickly grasp the *do's and don'ts* and *rights and wrongs* in "Piping Pointers." They keep veterans up-to-date on *"kinks"* that speed up work and step up efficiency of piping. For plants using this Crane service, it means fewer shutdowns—*more production!*

FREE—TO ANY PLANT—TO HELP SPEED VICTORY! Your local Crane Representative will gladly supply "Piping Pointers" on request. Or, write to the address given here.

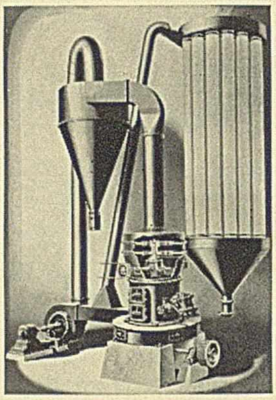
CRANE

CRANE CO., GENERAL OFFICES: 836 SOUTH MICHIGAN AVENUE, CHICAGO

VALVES • FITTINGS • PIPE • PLUMBING • HEATING • PUMPS

NATION-WIDE SERVICE THROUGH BRANCHES AND WHOLESALERS IN ALL MARKETS

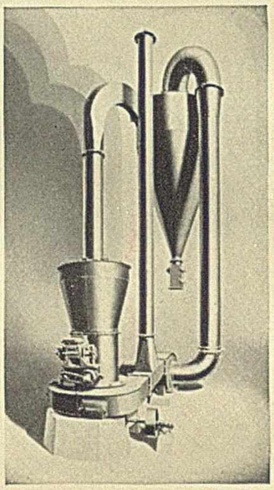
Solve Your PRODUCTION PROBLEMS *with* RAYMOND EQUIPMENT



PIGMENTS . . .

INCLUDING WHITE LEAD, LITHOPONE, TITANIUM PIGMENTS

To bring out the desirable characteristics in grinding pigment materials . . . . such as *low oil absorption, high covering power, extreme fineness and uniformity* . . . use the Raymond whizzer-type Roller Mill. It pulverizes and classifies the product to any fineness up to 99.97% minus 325-mesh, producing a superior quality finished material. It is easy to regulate and it gives greatly increased capacities . . . 25% to 50% on harder materials, and up to 100% on softer materials.



INSECTICIDES . . .

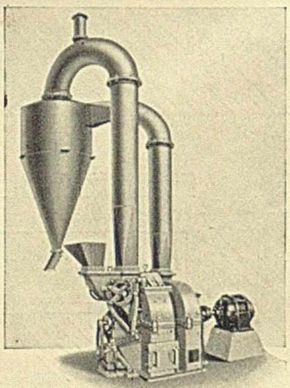
INCLUDING COPPER SULPHATE, SPRAY LIME AND OTHER CHEMICALS

In processing copper sulphate with the Raymond Imp Kiln Mill, the drying system of the mill can be controlled so as to remove exactly *four* of the five molecules of the *water of crystallization.* The material is pulverized to extreme fineness in the same operation. The resultant product is a mono-hydrated copper sulphate . . . a fine, dry, uniform powder, very economically produced. This is the standard method of manufacture so successfully used in many insecticide plants.

FOOD PRODUCTS . .

SOYA BEANS, CHOCOLATE MIXTURES, DRIED MILK POWDERS

The production of edible soya bean flour, both from the press cake and the solvent treated flakes, can be handled efficiently with the Raymond Imp Mill in combination with a Mechanical Air Separator, operating in closed circuit. The material is reduced in the mill and discharged to the separator, where it is classified to a fineness of 99.5% passing 300-mesh. The result is a fine commercial grade of soya bean flour, produced at low cost.



OUR TESTING LABORATORY ***is at your service***

in making experimental runs on your particular product for determining the proper equipment and method of production for your plant. Inquiries and samples are invited for examination.

Write for Catalogs

RAYMOND PULVERIZER DIVISION
COMBUSTION ENGINEERING COMPANY, INC.
1311 North Branch Street CHICAGO
Sales Offices in Principal Cities . . . In Canada: Combustion Engineering Corporation, Ltd., Montreal