CHEMICAL & METALLURGICAL ENGINEERING

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MILESTONES AND CORNERSTONES

FIFTY YEARS AGO our good dean of chemical engineering educators, Professor Alfred Holmes White of Michigan, was told by his teachers that the field of physics was practically closed. "The best you can look forward to, young man, is the opportunity to redetermine certain physical constants with a little greater accuracy — perhaps changing the fourth decimal place." Yet today, in a very real sense, this is the war of the physicists. The military decisions that may yet change the whole history of mankind for a fourth generation to come are now being born in the research laboratories of American universities and technological institutions.

The occasion of Colonel White's remarks was in Evanston, Ill. on June 15, when, as president of the Society for the Promotion of Engineering Education, he represented the profession at the dedication of the new Technological Institute of Northwestern University. Other distinguished engineers, scientists and educators shared the limelight with political leaders of the state and nation and with men like Donald Nelson and General Knudsen, who recognized in this event another step in the mobilization of science and engineering in the present national emergency.

The dedication could scarcely have come at a more appropriate time to emphasize the importance of our technological educational institutions to the welfare and safety of our country. President Karl T. Compton of M.I.T., whose address dealt with the future of engineering education, digressed long enough to note that the Office of Scientific Research and Development has already entered into 663 contracts with educational institutions for the performance of research and development work with but one objective—to improve our war effort. He could not even hint at the nature of the investigations "that have already shown promise of becoming important factors in the forthcoming military decision."

Closely paralleling the war work in the universities is that in the industrial research laboratories, where more than 200 contracts have been placed with about 75 commercial firms. To our knowledge, one company with a $5,000,000 research and development budget is today devoting 90 percent of its energies to the Victory effort, but, of course, only a small part of this is on direct OSRD contact. Such is the change from that first industrial research laboratory in the United States which Dr. Compton told us was established in 1834 by the Merrimack Manufacturing Co. in Lowell, Mass. and had as its objective the study of the chemistry of cow dung and of substitutes for cow dung as chemicals used in calico dyeing. Today that laboratory's modern successor is working on more offensive agents of chemical warfare and there is no "e" in the kind of "dying" with which it is now concerned!

Chemical engineering received a high tribute from President Compton when he remarked that "future improvements in engineering education may be expected to follow along a path which has been laid out by the chemical engineers." He traced the change from the earlier method of studying the details of a diversity of manufacturing processes to the modern approach through an integrated conception of fundamental unit operations. "This new concept . . . has resulted in chemical engineering's becoming one of the most useful and active of all engineering professional fields. The students in this program develop a power to handle situations rather than to absorb a mass of detail applicable only to appropriate specific situations."

Dr. George O. Curme, Jr., of Northwestern's class of 1909, saw in the new Technological Institute an important parallel with "Research in Industry," which was the title of his address. Today research squads are used like task forces in which all types of talents and weapons are combined to reach the desired objective. The tremendous physical plant of the Institute, providing ten acres of floor area in a building 500 ft. wide and 342 ft. deep, brings the departments of chemistry and physics into close association with the four major branches of engineering—chemical, civil, electrical and mechanical. Dr. Curme feels that this closer, mutually stimulating cooperation can open up new frontiers far beyond the present horizons of research.

Both the Hon. Jesse Jones and the equally honorable Donald Nelson stressed the importance of the new facilities in relation to the post-war world. The Secretary of Commerce said that "those who will pass through the Technological Institute of Northwestern, benefitting from both theoretical and practical knowledge, can contribute much when the day for peace-time conversion comes." Nelson said, "We need and must have engineers, not only to speed up the war program, but to aid us with the great task which will be ours when peace comes, as come it will. We are going to need engineers to mobilize for peace with the same enthusiasm, energy and determination that we are mobilizing for war. Now, and in the future, within the walls of this Institute and outside it in the laboratories and factories of industry, there can be no faltering in the continuous search for ways of achieving greater and greater results for mankind."

Such were the highlights in dedicating a great new facility for technological education. In a broader sense it was a dedication of all technology and of all its practitioners to a new and greater spirit of service to the nation and to the cause of human liberty throughout the world.

AGAINST THE PUBLIC INTEREST

Indictments have been returned at South Bend, Indiana, against numerous chemical companies and their executives. It is not yet proper here to comment on the guilt or innocence of the defendants so brought to bar. But it is appropriate, in fact we believe it important, to point out that the action of the Department of Justice in these proceedings has no justification, because it is very definitely contrary to the public interest.

The Department of Justice has appropriately from time to time investigated the basis on which chemicals are marketed. It is the duty of that Department to see that the law regarding restraint of trade is in force. Under all ordinary conditions there should be prosecutions when there seems to be valid evidence of serious violation of the law. So much for normal conditions.

Present conditions are very different. In the first place, the Department itself has been doing a slovenly job by bringing up cases which Federal judges have thrown out without defense because no proof of guilt was submitted. In the second place, there is evidence in the writings of Assistant Attorney General Arnold himself that it is his purpose to accomplish reform by means of these Court prosecutions. In the third place, even the Department of Justice ought to be busy at jobs which help win the war; certainly they should not take time from far more urgent jobs of their own. Nor should they be permitted to take thousands of man-days of useful war effort away from chemical companies to defend themselves against such attacks.

In due time we shall find out what the Courts say about the recent indictments. But in the meantime, it is safe to conclude that the Department of Justice's activities while perhaps technically and legally proper, are dangerously close to treason. They are in effect equal to the taking of thousands of soldiers away from the fighting front in order to meet trumped-up traffic charges for speeding alleged to have happened months ago.

It seems high time that President Roosevelt should take charge of this situation and correct it. This can be done without any sacrifice of the Department's right to enforce the law, a right which is also its duty.

THAT LONGER LOOK AHEAD

One of the greatest obstacles to date in the whole war-time construction program has been the uncertainty as to requirements. Some chemical companies were alert enough to see the need and get ready for them. In days when priorities were not so difficult to obtain, a few organizations built plants a little beyond official requirements and are now able to do a better job because of that happy foresight. Unfortunately those are exceptions. Too often capacities were established and approved when those in the government responsible for supplies knew that actual requirements far exceeded the official figures. Nevertheless, there must be no complaining. It is industry's job to do its utmost to prepare itself to produce what in fact will be needed to sustain our war effort.

An executive of a leading chemical company writes us as follows:

> "With the very serious reduction of raw material supplies entering this country following the attack on Pearl Harbor and the continued prosecution of German submarine attacks on our shipping, it becomes increasingly evident that within a year's time, we will need extensive expansion of some of our chemical industries in order to fill the gap caused by the growing scarcity of natural raw materials.
>
> In spite of this rather obvious situation which is developing, I know of no effort being made by our government to forecast this condition and to provide for it by expanding chemical plants other than those that some day will make our synthetic rubber. No country-wide survey has been made to estimate the essential requirements for substitutes that will soon be very badly needed. Even our Navy is rushing around trying to find substitutes for materials which have been taken away from them while in the meantime the enemy's submarines continue to sink our supplies of other materials which might have been used as substitutes for the substitutes. There is need for some agency, governmental or private, to make a thorough-going study of the needs for chemical substitute materials, to take the place of natural materials no longer available in this country."

This has an important bearing, too, on the problem of providing new plant capacity in the chemical process industries—a subject which is reviewed at some length in the current Chem. & Met. Report on War-Time Construction. (See pp. 99 to 106 of this issue.) We have now got to fight for such new facilities as are absolutely essential to keep the war program rolling.

ON THE POLITICAL FRONT

MANY observers of Washington have lately pointed out that the desire for reelection is occasioning some highly undesirable delays in legislative action. Politics are affecting many decisions on war policies that ought to be made strictly on merit. The unwillingness to vote promptly on a tax bill, the unwillingness to give the Army more of the young men of 19 to 20 years of age, and the other postponements of embarrassing votes until after November, are the kind of criticisms commonly cited. Those who have influence with members of Congress may to some small degree offset these tendencies for delay. They can emphasize to these members that aggressive patriotic effort is the best kind of politics today. Facing unpleasant votes frankly ought to be made the finest argument for reelection. In a few cases it may be.

WASHINGTON HIGHLIGHTS

COMPETENT ENGINEERS in the top organization of both the War Manpower Commission and the Army Specialists Corps understand the technical personnel problems of industry. Likewise they know that the Army needs engineers in industry just as badly as it needs competent military personnel in uniform. This is encouraging. We cannot expect that all diversions of much needed men from civilian posts to non-technical Army jobs can be stopped at once. But we can hope that the recent trend of taking too large a number of key personnel will be reversed. Those who will establish the guiding principles here are Dr. William O. Hotchkiss, Deputy Director General, Army Specialists Corps, on leave as president of Rensselaer Polytechnic Institute, and Dr. Edward C. Elliott of the War Manpower Commission, president of Purdue University.

DEFERMENT of key employees must be requested by employers. Washington does not think it is in the public interest for management to be unwilling to carry through aggressively its arguments for deferment when highly skilled personnel is likely to be drafted for military service in which that skill is less essential. It is one thing to provide a hideout for slackers; it is an entirely different thing to decline to make necessary and urgent requests for deferment of essential personnel. Management has a real responsibility in this matter.

PRICE RISES start on the farm. In the first four months of 1942, the sales of farm goods returned 50 percent more dollars to farmers than in the corresponding period a year ago. Processors feel very sharply the pinch between a frozen price ceiling and these rising costs of both raw materials and labor. No amount of increased business helps much in these circumstances.

T.V.A. has had another reprieve. Congress seriously considered limiting its disbursements to the actual appropriations but it was evident that the corporate activities of this quasi-government body would thus be severely restricted. Hence the use of revolving funds has been continued. But the attack on T.V.A., which was by no means the last one to be expected, shows that Congress does not like to relinquish the administrative control of funds, even when there is no question as to the desirability of the spending.

RAILROAD CAR MOVEMENT must be speeded. Every plant management must, and it is a real MUST, arrange for prompt loading of cars when spotted on their sidings and immediate unloading of deliveries. Any establishment failing to cooperate promptly is likely to be deprived of car service.

RECRIMINATION runs in cycles. After each military set-back there is a new wave of criticism. The loss of Libya occasioned one of the most bitter uprisings of everyone against everybody else in the Capitol. This is democratic human nature in action. If it does not destroy too much of the enthusiasm for support of war undertaking, it is a good symptom.

SPENDING something over fifty billion dollars next year by the Army, Navy and Lease-Lend agencies in military effort will depend primarily on a single factor—availability of essential raw materials, primarily metals and chemicals. Hence there must be, first, a maximum production of every wanted commodity and, second, a rigorous conservation to stretch limited supplies over the maximum possible essential service.

GAS WARFARE is expected. The warning of the President that the United States will retaliate if Japan persists in using toxic chemicals on the Chinese was more than a gesture. Definite preparation is being made. Chemical Warfare Service is establishing a huge new training center where it will prepare both defense and offense personnel for this kind of fighting. America does not wish it, but does not intend to remain unprepared.

SHORTAGES of three things most worry Washington. (1) We have nothing like as much metal to cut up into implements of war as we could use effectively with present manpower and present plant capacity. (2) Even present production cannot be moved promptly to the fighting fronts because of shortage of ships. (3) Lack of rubber threatens to force civilian activities below what is regarded as a minimum essential level, even for war-time. Many decisions of official Washington that otherwise cannot be understood root in these three worries.

PLANS of the new special Rubber Investigation of the House of Representatives were pretty well forecast by its newly appointed counsel, Elliot E. Simpson. Among other things, this gentleman stated frankly that he will try "to prove conclusively that America can supply more than enough rubber for all military and civilian needs." Judging from such preconceived conclusions, another political pillaging of industry is in the offing.

Production of Acetylene by Thermal Cracking of Petroleum Hydrocarbons

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Chem. & Met. INTERPRETATION

In common with most chemicals and chemical raw materials, acetylene is becoming increasingly important in America's Victory program. Pyrolysis of hydrocarbons has long been recognized as a potential source of the gas, but technical difficulties have heretofore ruled out commercial installations. How these were overcome is related here by one of the men largely responsible for the success of a project to make cracking a practical source of acetylene.—*Editors.*

Acetylene has long been recognized as one of the most important and versatile starting materials for organic syntheses, particularly for the preparation of aliphatic compounds. Although its reactivity with a great variety of substances was early recognized and made use of by the chemist in the laboratory, only within comparatively recent years has it been applied to commercial syntheses. The first important development in this direction was the conversion of acetylene, obtained from calcium carbide, to acetaldehyde as the first step in the production of acetic acid. This industry has now assumed very large proportions both in this country and abroad. Some of the newer chemicals now being manufactured from acetylene are vinyl acetylene, vinyl acetate and the halogen derivatives —tetrachlorethane and trichlorethylene.

A much larger field of usage for acetylene is now opening up in the manufacture of butadiene for synthetic rubber. In Germany, coincident with the development of a self-sufficiency in synthetic rubber, the construction of calcium carbide plants was stepped up several-fold. While in this country the petroleum industry offers possibilities of producing butadiene by cracking, there seems little doubt that acetylene will be a formidable competitor, due to both low cost and the purity of the butadiene obtainable by this method. We have mentioned vinyl acetylene as another product which is an intermediate in the preparation of the chloroprene rubbers. Thus, we see that acetylene is destined to play an important role in our National Victory Program.

ADVANTAGES OF THERMAL CRACKING

Let us consider the factors that recommend the thermal cracking method for the commercial production of acetylene. One obvious advantage of straight thermal pyrolysis of hydrocarbons to produce acetylene over the electric arc or silent discharge is that the necessary heat can be supplied by burning the byproduct gases, produced in the process, which consist mainly of hydrogen and methane. In other words, the cost of energy for the pyrolysis is included in the cost of the hydrocarbon material processed. The net saving of the thermal over the electrical method—with equal yields of acetylene—is the cost of the electrical power required in the latter method. At a cost of three mills per kwh. this saving would amount to about 1¼c. per lb. of acetylene, a substantial proportion of the total cost.

Another very important advantage following logically from the above

HISTORICAL—Edmund Davy[1] in 1836 discovered a new gas which he reported as being formed by the action of water on potassium carbide. He also reported a number of its important properties which leaves no doubt that the gas he was describing was acetylene. Berthelot named the gas "acetylene" and in a series of researches begun in 1860 made a very careful study of its physical properties. In 1862, Berthelot[2] showed that acetylene could be made by the direct union of carbon and hydrogen in an electric arc. In the same year Woehler[3] made the noteworthy observation that the gas was formed by the action of water on calcium carbide. This observation escaped notice until thirty years later when the reaction became of great commercial importance. Lewes[4] in 1894 converted ethylene to acetylene by direct thermal cracking, operating at temperatures of 900 to 1,500 deg. C. However, his yields of acetylene were very low. Later, Bone and Coward[5] produced small amounts of acetylene from methane, ethane and ethylene.

America pioneered in the development of a commercial method for producing acetylene. While Boehm[6] claimed in a patent application, filed in the United States November 5, 1891, the production of calcium carbide by heating carbon and an alkaline earth by means of an electric current, Wilson in this country is given the credit for making the first calcium carbide in the electric furnace. While attempting to produce aluminum in the electric furnace, he accidently discovered a new and practical method of making calcium carbide. On May 2, 1892 he recognized its importance for the commercial production of acetylene. Three days later he filed a patent application[7]. Henri Moissan reported similar discoveries on December 12, 1892 before the Academie des Sciences in Paris. In 1894 Lewes[8] in London first employed acetylene in a burner for lighting purposes. A greater development was yet to come. Twelve years later in 1906 acetylene was first applied in burners for the welding and cutting of metals.

The production of calcium carbide grew rapidly after the discovery of acetylene welding, reaching a volume of approximately 250,000 tons in 1928. Since then, the increase in plant capacity has not been very rapid, but we now appear to be on the threshold of a greatly increased usage of acetylene and its production by high temperature pyrolysis of hydrocarbons as a competitor for calcium carbide warrants careful consideration. This is particularly true now due to the threatened shortage of electric power as a result of the demands of the Defense Program in the production of aluminum and magnesium. Power is the largest single item of cost in calcium carbide manufacture, amounting to approximately 3,000 kwh. per ton or equivalent to about 4.5 kwh. per lb. of acetylene.

ELECTRICAL CRACKING

Acetylene is a very endothermic compound, having a heat of formation from its elements of about 59,000 cal. In order to produce it from a hydrocarbon richer in hydrogen, temperatures above 1,100 deg. C. are required. For hydrocarbons higher than methane, employing contact times of about 0.1 sec., optimum yields of acetylene require temperatures of approximately 1,225 deg. C., and for methane itself in the neighborhood of 1,500 deg. C. It will be quite evident that one of the reasons for the slow progress in this direction has been due to the difficulty in attaining these elevated temperatures. There are very few materials at our disposal that will with-consideration is that plant location is not confined to localities of cheap and adequate power supply, a necessary requirement for both calcium carbide production or the use of an electric method of cracking. A location chosen because of suitable power conditions might not be where hydrocarbon materials are cheap and abundant. For thermal cracking a wide choice of plant locations is possible where ample supplies of petroleum or natural gas hydrocarbons are available at a low cost.

Workers in the field of high temperature thermal cracking of hydrocarbons to acetylene have been aware of the possible advantages which have just been pointed out; they have furnished the incentive for the development discussed in this article.

Little progress was made on straight thermal cracking until 1926 when Wulff in this country carried out an extensive study of high temperature, thermal cracking with the view to developing a commercial method for the production of acetylene. He was the first one who recognized the great importance of a combination of short contact time and rapid quenching of the cracked mixture, in obtaining high yields. A series of patents[18] have been issued to him covering the thermal cracking of hydrocarbons to acetylene employing temperatures above 1,500 deg. F., a contact period of less than five seconds, and rapid cooling of the product.

Fischer and co-workers[19] in a series of investigations begun in 1928, showed that by controlling the contact time, good yields of acetylene with very little carbon formation could be obtained at atmospheric pressure.

Simultaneously, other laboratories investigated the pyrolytic method. Tropsch and Egloff[20] studied the pyrolysis of methane, ethane, propane and butane under reduced pressure. Subsequent work was reported by Tropsch, Parrish and Egloff[21] on the pyrolysis of the gaseous olefins. Pyzel[22] showed the thermal cracking of natural gas to acetylene and ethylene, injecting additional natural gas into the hot gases issuing from the converter to produce further quantities of ethylene.

In 1934 a program for commercializing the process of thermal cracking to acetylene was initiated by the Tennessee Eastman Corporation, and it is the purpose of this article to report the development.

LABORATORY TUBE CRACKING

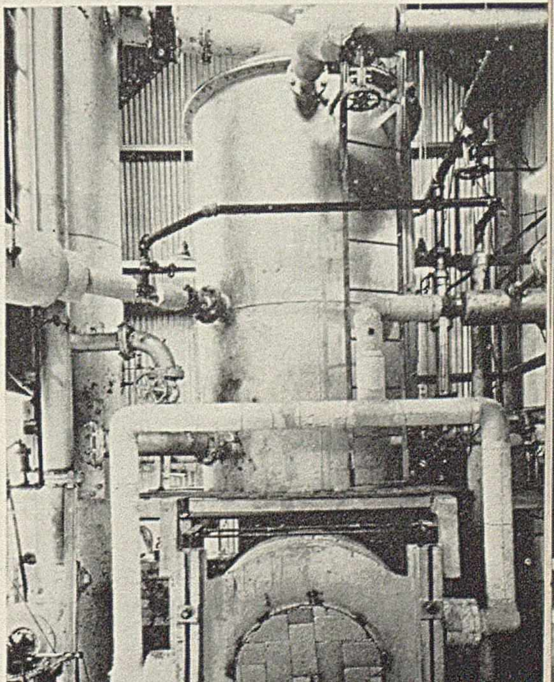
In the earlier work, the optimum conditions for cracking the various saturated, aliphatic hydrocarbons were determined in a laboratory furnace producing 4 to 10 cu.ft. of cracked gas per hr., depending on the type of hydrocarbon processed. In the furnace, a carborundum tube ½-in. i.d. x 2-in. o.d. and 6 ft. in length served as preheater section. It extended through the high temperature zone where the tube was enclosed in an alundum sleeve wound with molybdenum wire. Around the winding was a tight steel box packed with silica-free alundum sand. A slight pressure of hydrogen was maintained in the enclosing chamber as a reducing atmosphere to prevent oxidation of the molybdenum wire. Centered in the carborundum tube, was an alundum tube $\frac{23}{64}$ in. i.d. for the dual purpose of enclosing a platinum-rhodium thermocouple and acting as a core-buster so as to allow a very high gas velocity and consequently a very short contact time.

Gas temperatures of 1,500 deg. C., readily obtained with the furnace, were sufficient to crack methane, natural gas, mixtures of heavy hydrocarbons separated from natural gas, as well as propane, butane and natural gasoline. In all of the work, steam diluent was used and contact times were less than 1/10 sec.

In Table I are shown the results obtained in cracking 28-70 grade natural gasoline at various temperatures. It will be noted that the entire temperature range of acetylene cracking is covered, up to a point where over-cracking occurs. An idea of the mechanism of the pyrolysis process may be gathered by referring to Fig. 1, in which the results are plotted graphically showing the yield of the various carbon containing constituents obtained in the pyrolysis. Portions between the curves show the amount of the products formed at the various temperatures.

It will be noted that even in pyrolysis of natural gasoline, which is a mixture of paraffin hydrocarbons containing five or more carbon atoms, ethane is the highest member of the paraffin series present at slightly above 1,000 deg. C. It disappears above 1,150 deg. C. and the olefins are progressively converted into acetylene—butylene disappearing at about 1,175 deg. C. and propylene at a temperature of 1,350 deg. C. which is optimum for acetylene. An interesting fact is that methane increases until the ethane disappears and then remains substantially constant until 1,400 deg. C. is approached. Benzene is a very stable compound at high temperatures due to its endothermic

One type of horizontal furnace in semi-works scale. Air and gas-steam preheater are in the vertical shell



stand the high temperatures, have sufficient heat conductivity and at the same time be non-catalytic.

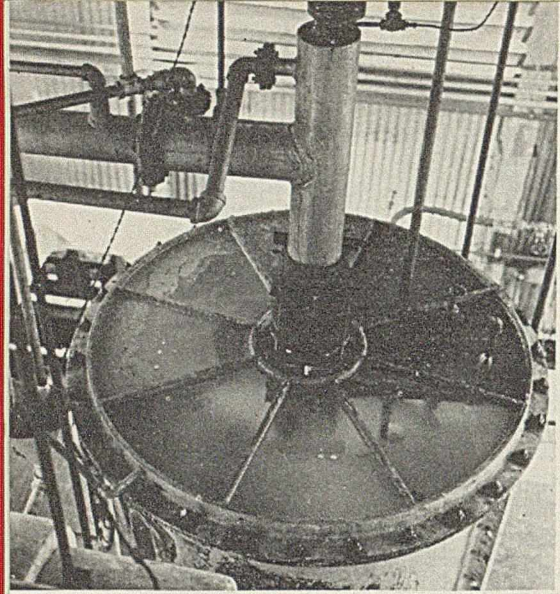
Investigators, in searching for a means of heating saturated hydrocarbons to temperatures required for acetylene production, first chose the electric arc and silent electrical discharge methods. It was possible by passing a rapid stream of hydrocarbon gas or liquid through the arc or silent discharge, to heat it to a very high temperature and by quickly quenching the mixture to obtain appreciable quantities of acetylene. However, in order to obtain good yields it was necessary to operate under reduced pressure or in the presence of an inert diluent. In employing the silent electric discharge the hydrocarbon gas was passed through the apparatus at a low pressure of the order of .01 to 0.1 atm. Thus, on account of the mechanical difficulties involved and the high power requirements the electrical methods did not appear to offer advantage over producing acetylene through calcium carbide.

In the accompanying table are summarized the energy requirements per lb. C_2H_2 as determined by investigators using electrical cracking methods.

It will be noted that the average requirement is about 4.5 kwh. per lb. of acetylene. In calcium carbide manufacture there is a power expenditure of about 3,000 kwh. per ton or 1.5 kwh. per lb. Now when we consider that it requires about 3 lb. of calcium carbide to make 1 lb. of acetylene, the electrical energy is substantially the same for the two methods. Consequently, the economics of C_2H_2 production by pyrolyzing hydrocarbons with electrical energy do not make it appear attractive.

Investigators	Hydrocarbon Cracked	Kwh. per Lb. Acetylene
L'Air Liquid Society[9]	Gas Oil	4.9*
Peters and Pranschke[10]	Methane	4.7
Peters and Wagner[11]	Methane	5.1
Gmelin and Eisenhut[12]	Methane	5.35
Eisenhut, Stadler and	Methane	4.3
Baumann[13]	Methane	4.3
Baumann, Stadler and Schilling[14]	Methane and Homologues	4.35–4.9
Eisenhut, Schilling and Baumann[15]	Methane	5.4*
Baumann, Stadler and Schilling[16]	Propane	4.2
Miloslavskii and Glizmenenko[17]	Solar Oil	4.2

*For Acetylene and Carbon Black.



Top of the vertical furnace showing water-cooled, mercury-sealed packing gland

character and the amount formed continues to increase up to about 1,250 deg. C.

Table II shows a similar pyrolysis study on propane in which the cracking range was extended to lower temperatures. Substantially the same contact times were used as in the case of natural gasoline which makes possible a direct comparison of the two as potential, commercial raw materials. Inspection of the results, shown plotted in Figs. 1 and 2, reveals great similarity. The main differences noted are that propane cracks to optimum yields of acetylene and ethylene at somewhat lower temperatures and the over-all yields of desirable products are considerably improved. In fact, better yields are expected at lower temperatures since the amount of hydrocarbon feed converted to carbon monoxide and carbon dioxide is less, as is also the amount of carbon and tar formed.

Noteworthy, as with natural gasoline, is the fact that practically no methane was formed below 1,000 deg. C., although at this temperature 91 percent of the propane had disappeared. However, approximately 73

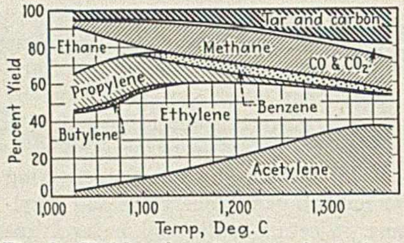


Fig. 1—Yields of various products from pyrolysis of natural gasoline

percent of the propane had been converted to hydrocarbons containing two carbon atoms—ethane, ethylene and acetylene—with only about 13 percent and 3 percent of propylene and benzene, respectively, being formed. This behavior of propane during pyrolysis in the lower temperature range gives us an insight into the probable mechanism of the cracking. The predominant reaction appears to be the production of methyl, methylene and possibly methine radicals which then combine to form ethane, ethylene and acetylene. At higher temperatures, above 1,000 deg. C., methane forms as a side reaction at the expense of ethane, approximately 25 percent of the ethane disappearing by this route. From the point where the ethane disappears there are no further quantities of methane or the olefines formed. This would tend to show that at high temperatures no methane is formed at the expense of the unsaturated hydrocarbons. At still higher temper-

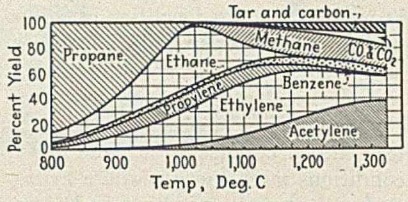


Fig. 2—Products obtained by pyrolysis of propane in laboratory furnace

atures, as indicated in Table I, the methane begins to crack.

SEMI-WORKS TUBE FURNACES

After determining the optimum conditions for acetylene cracking in the laboratory furnace as regards steam dilution, temperature and contact time, employing various starting materials, the next task was to duplicate the results on larger scale and in unit sizes that could be expanded directly to commercial scale.

The first step was to build a gas-fired furnace with larger carborundum tube. As in the laboratory furnace, it was necessary to use core-busters to obtain the high gas velocities at short contact time for high rates of heat transfer. The first furnace was horizontal containing a single tube. It was increased in size as larger tubes became available from the manufacturer.

In order to obtain the high temperature level within the tubes it was necessary to maintain a very high flame temperature in the com-

Table I — Pyrolysis of Natural Gasoline

Sample No.	1	2	3	4	5	6	7	8	9
Temperature, °C	1016	1068	1106	1128	1186	1252	1306	1344	1370
Volume increase	3.30	3.67	3.99	4.23	4.54	5.20	5.85	6.20	6.48
Carbon balance—Percent	92.4	93.1	92.9	92.4	90.7	88.4	85.0	85.6	81.2
Gas analyses—Percent									
Carbon dioxide	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.8	1.1
Acetylene	1.5	5.5	6.9	9.3	11.6	15.4	16.9	17.5	16.5
Ethylene	38.5	33.8	34.4	31.8	27.7	18.3	11.5	9.6	7.7
Propylene	10.6	11.5	7.7	6.0	3.2	0.9	0.3	0.2	0.1
Butylene	0.4	1.1	0.5	0.1	0.1	0.0	0.0	0.0	0.0
Benzene	—	—	0.5	0.9	0.9	1.1	0.8	0.6	0.4
Oxygen	0.2	0.0	0.1	0.1	0.1	0.2	0.2	0.2	0.0
Hydrogen	20.1	23.1	24.9	26.7	31.0	38.5	45.6	46.7	51.0
Carbon monoxide	0.6	0.7	1.2	1.5	1.7	3.3	4.7	6.2	6.5
Methane	1.5	13.9	18.7	23.5	23.6	21.4	19.1	17.6	16.1
Ethane	26.5	10.9	4.7	0.1	0.0	0.0	0.0	0.0	0.0
Nitrogen	0.2	0.2	0.5	0.0	0.2	0.4	0.4	0.6	0.6

Table II — Pyrolysis of Propane

Run number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Temperature, °C	800	850	900	950	1000	1025	1050	1075	1100	1125	1150	1190	1225	1250	1275	1300	1325
Steam dilution	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5	6.5
Expansion	1.09	1.16	1.29	1.51	1.64	1.86	1.90	2.14	2.28	2.42	2.56	2.77	3.00	3.11	3.26	3.50	3.66
Percent carbon balance	100	100	100	100	99.6	99.3	98.6	98.0	97.6	96.4	96.6	96.1	94.2	92.8	92.5	93.2	91.5
Percent yield—C_2H_2 + C_2H_4	1.96	4.52	10.65	20.3	25.5	36.1	37.9	47.5	51.8	56.2	58.7	61.3	61.0	60.2	58.8	57.8	57.6
Analysis of cracked gas —vol. percent.																	
CO_2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.2	0.4	0.4	0.6	0.6	0.7
C_2H_2	0.2	0.2	0.4	1.1	2.4	3.7	4.0	6.2	7.5	8.9	10.5	13.0	14.8	15.8	15.9	16.4	15.3
C_2H_4	2.5	5.7	12.0	19.4	20.9	25.4	25.8	27.1	26.5	26.0	24.0	20.3	15.7	13.3	11.2	8.9	8.3
C_3H_6	1.9	4.2	7.0	8.4	7.7	6.8	6.7	5.3	4.6	3.5	2.7	1.4	0.9	0.6	0.4	0.2	0.0
C_6H_6	0.8	0.9	0.8	0.9	1.0	0.9	0.7	0.9	0.8	0.8	1.0	1.2	1.1	1.0	1.1	0.9	0.7
O_2	—	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.1	0.1	0.1
H_2	4.0	6.7	11.3	16.1	18.9	23.0	23.4	27.3	30.0	32.6	35.0	39.0	43.5	45.7	47.8	49.8	51.7
CO	—	0.1	0.1	0.1	0.1	0.3	0.4	0.5	0.8	0.9	1.2	2.0	2.7	3.2	3.9	5.7	7.2
CH_3	—	—	—	—	—	3.3	6.3	15.5	17.6	20.1	21.4	21.1	20.4	19.9	18.6	17.0	15.7
C_2H_6	10.7	15.5	22.0	33.7	40.0	36.2	32.3	16.7	11.6	6.6	3.5	1.4	0.2	0.0	0.0	0.0	0.0
C_3H_8	79.8	66.5	46.1	20.1	8.8	—	—	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N_2	—	—	—	—	—	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.2	0.1	0.4	0.4	0.3

Table III—Pyrolysis of Natural Gasoline with Recirculation of Ethylene

Run number	1	2	3	4	5	6	7	Calc.
Temperature, °C	1310	1266	1308	1290	1290	1306	1307	1300
Mol fraction—gasoline	0.214	0.162	0.208	0.211	0.199	0.224	0.217	0.215
—recycle	0.786	0.838	0.792	0.789	0.801	0.776	0.783	0.785
Steam dilution	4.8	4.5	4.5	5.0	4.4	4.0	4.4	4.8
Expansion—measured	2.55	2.12	2.44	2.34	2.37	2.21	2.58	—
—calculated	2.54	2.09	2.42	2.37	2.32	2.46	2.54	2.40
Percent carbon balance	92.5	91.6	89.9	90.4	90.4	87.1	89.1	91.3
Percent yield C_2H_2	51.9	53.5	53.2	49.4	48.9	46.4	51.5	48.4
Analysis of cracked gas —vol. percent								
CO_2	0.6	0.4	0.4	0.4	0.4	0.4	0.4	0.5
C_2H_2	15.3	14.5	16.0	15.4	14.7	14.8	15.4	15.4
C_2H_4	15.2	18.3	14.8	17.0	17.3	16.1	14.6	18.3
C_3H_6	1.0	1.0	0.8	0.8	0.8	0.8	0.5	0.9
C_6H_6	0.6	0.8	0.9	0.8	0.8	0.6	0.6	1.1
O_2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
H_2	40.1	37.7	41.0	39.0	38.8	40.9	41.8	38.5
CO	5.3	3.0	3.8	3.3	3.5	3.4	4.5	3.3
CH_4	21.1	23.1	21.8	22.8	22.9	22.4	19.9	21.4
N_2	0.6	0.4	0.3	0.3	0.6	0.4	1.2	0.4

bustion chamber. This was accomplished by employing an air preheat of 500-600 deg. C. Preheat was obtained from the combustion gases leaving the cracking chamber and passing through an auxiliary preheater section. The incoming hydrocarbon feed and steam mixture was likewise heated[23] to 800 deg. C. in alloy steel coils in the same preheater assembly.

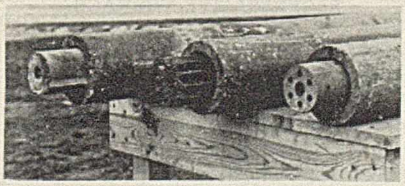
Although laboratory cracking results were duplicated with the various hydrocarbons processed, refractory and mechanical difficulties arose. Trouble was soon encountered with the horizontal type of furnace due to sagging of the carborundum, although the unsupported tube span was only over a 4-ft. length. At first this was thought to be due to rigidity of connections at the two ends of the tube but the sagging still persisted after flexible water-cooled connections were provided at the tube ends. The strains were apparently induced by compression and tension at the top and bottom respectively, because the tubes failed from circumferential cracks after only a few days. It is to be pointed out that we were attempting to operate in an unexplored field for carborundum tubes, as far as temperature and rate of heat transfer through the wall was concerned. Also the tubes were larger in diameter and length than had been fabricated heretofore. The illustration (p. 79) shows one type of horizontal furnace. The gas-steam and air preheater is shown above the furnace enclosed in the vertical shell.

In the attempt to obtain improved tube life it was decided to build a vertical furnace. It was designed for a carborundum tube 4 in. i.d. x 5¾ in. o.d. and 8 ft. in length, provided with a 3¼ in. diameter core-buster of the type to be described. The bottom of the tube was rounded to fit into a machined water-cooled seat made tight with an asbestos-lined copper gasket. The top of the tube extended through a loose hole in the refractory lining. The top of the tube was gas tight, yet perfectly free to move in all directions by a sylphon type packing gland[24] water cooled and provided with a mercury seal.

In operating the furnace the gas-steam mixture, preheated to 800 deg. C., entered the bottom of the tube where the pressure was balanced with respect to the combustion chamber surrounding the tube by the use of a Hagan regulator. The balance was maintained by operating a by-pass valve on the Nash blower pulling the gas through the tube. At the high-gas velocity a 3 lb. per sq.in. pressure drop occurred from the bottom to the top of the tube and yet the top seal was gas-tight.

The underside of the domed top had a suspended lining of high-alumina, refractory shapes. The accompanying illustration shows the dome, the top of which was water-cooled. The water-cooled, mercury-sealed packing gland is also visible. Connecting with the gland was a 2-in. water cooled pipe 15 ft. in length which cooled the cracked gas to 400 deg. C. before it entered a gas seal box type of quencher. The velocity of the gas was so great and consequently the heat transfer was so high that no tar deposited in the wall of the tube. In other words, the inside wall temperature was never lower than the dew-point of the tar. Based on this experience a fire-tube boiler, designed for the same rate of heat transfer, would be practical on a larger unit to generate steam for power required in concentrating the gas and the necessary low pressure steam for gas dilution.

Types of core-busters. One shown at the left proved most satisfactory



A considerable study was made of core-busters. The most satisfactory was one with smooth sides and with centering lugs. A center hole was provided for insertion of the thermocouple.

The furnace was fired by two tangentially placed burners[25] located near the top of the furnace. They were provided with sylphon diaphragms to take up unequal expansion due to the use of preheated air.

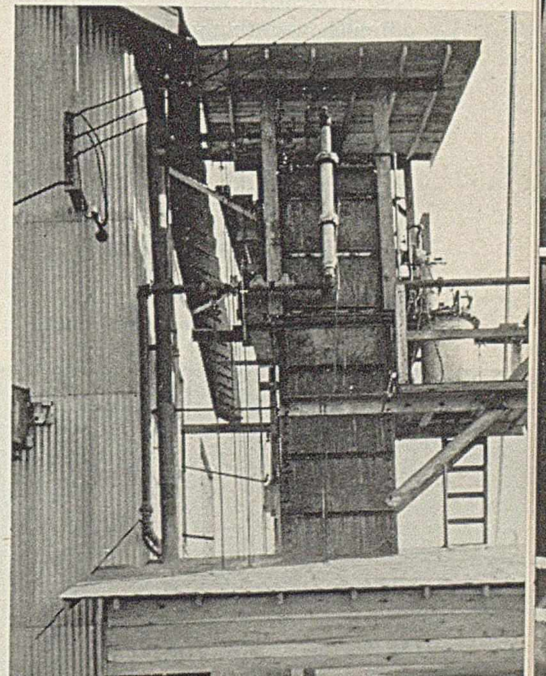
Operation of the vertical tube furnace was much more successful than with the horizontal type. After a period of over a year's operation on a 24-hr. basis, a three month tube life was established. Yields of acetylene were equal to those obtained in the laboratory. Carbon was blown on the average every 36 hr., while on the laboratory furnace it had to be blown every hour.

RECIRCULATORY CRACKING

Inspection of Table I, containing results on natural gasoline cracking, indicates that Sample 6 represents about the optimum cracking condition. Acetylene and ethylene are present to the extent of 15.4 and 18.3 percent respectively. For greatest economy of raw material both the acetylene and the ethylene should be utilized. A simple cost computation will show that the process would not be very attractive if operated only for acetylene unless cracking were carried out at a considerably higher temperature.

It seemed most likely that in the majority of cases it would be most

Semi-works regenerative furnace with seal box type of quencher



desirable to be able to operate the process economically for acetylene alone. It was thought that this might be accomplished by some type of recirculatory cracking. In order to test the idea the gas was separated[26] into three fractions—concentrated acetylene, concentrated ethylene and fuel gas. By compressing the cracked gas to 300 lb. gage pressure and using a proper choice of solvents we were able in one stage absorption to produce a 70-80 percent acetylene gas, a 50-60 percent ethylene, and leave a fuel gas having a calorific value of about 450 B.t.u. per cu.ft.

Cracking with recirculation of the ethylene fraction[27] was most successful. In addition to ethylene, some methane representing about 60 percent of that formed in single pass cracking was also recirculated. The success attained in recirculation of ethylene indicated that at a definite contact time and cracking temperature, for a given hydrocarbon feed, there was an equilibrium established, and by returning the equilibrium amount of ethylene the net effect was that the fresh hydrocarbon feed is pyrolyzed directly to acetylene. The enhancement in acetylene yield, based on new charge stock fed, due to recirculation of concentrated ethylene is illustrated quite simply in butane cracking. In the table below is a comparison of results in single pass and recirculatory cracking.

	Single Pass Vols. Feed Gas	Single Pass Vols. Cracked Gas	Recirculation Vols. Feed Gas	Recirculation Vols. Cracked Gas
Butane	100	—	26.0	—
Acetylene	—	55.0	—	27.4
Ethylene	—	56.7	29.5	29.5
Methane	—	86.0	44.5	62.0
Hydrogen	—	162.0	—	76.5
Benzene	—	1.2	—	1.0
Carbon Monoxide	—	12.0	—	8.7
Carbon Dioxide..	—	3.0	—	1.5
Acetylene Yield (Based on Butane Fed)		27.5%		52.3%

It is to be noted that the yield of acetylene based on butane fed has been practically doubled and at the optimum operating point, represented by the above condition, there is no net gain in ethylene during the cracking. In effect, the recycled ethylene is converted into acetylene thus making it a low cost acetylene process without a byproduct ethylene credit. An additional advantage is that about 10 percent less heat is required with recirculation than in single pass cracking.

Recirculation of ethylene has accomplished the attainment of maximum acetylene yields at temperatures which are conservative as far as refractory life is concerned. Such yields can only be approached but never equalled at much higher temperatures in single pass cracking.

Table I contains results on a single pass cracking of 28-70 grade natural gasoline. Table III is on the same material using recirculatory cracking. The calculated run in the latter table is based on Run 6 from Table I. Noteworthy is the fact that there is no fundamental difference in the type of gas analysis obtained in single pass and recirculating cracking since the calculated run is almost identical with the experimental. The acetylene yield, however, was increased from 26 to 48.4 percent. Thus the dual purpose served by this development was the concentration of acetylene to a point where it was more suitable for chemical conversion and the yield of acetylene was almost doubled.

The development of recirculatory cracking firmly established the economy of the process as far as raw material costs were concerned. However, an engineering study of the investment cost for a plant using tube furnaces for cracking did not present any too favorable picture. It did not seem practical, for many reasons, to build furnaces with more than a limited number of tubes per unit, which would lead to high labor costs. Other factors operating in the same direction would be frequent blowing of carbon and also tube replacements.

Another serious disadvantage was that indirect transfer of heat through tubes for heating hydrocarbons to the neighborhood of 1,300 deg. C. required extremely high flame temperatures which could only be attained by using preheated air for combustion. The high flame temperatures had not only a very punishing effect on the carborundum tubes but also on the refractory of the furnace linings. For the latter only an expensive, high alumina brick could withstand the temperature without considerable shrinkage and spalling.

REGENERATIVE FURNACE

The alternate method for bringing a gas to a high temperature is by its direct contact with a surface which has been previously heated—in other words, in a regenerative type of furnace. This method of cracking had not been overlooked in the early work but no satisfactory solution was found. In some early types of furnaces broken carborundum packing was alternately fired with combustion gas and in turn gave up its heat to the hydrocarbon cracked. However, the acetylene yields did not compare with those obtained in tube-cracking. Also trouble was encountered with a building up of carbon which was not removed during the heating cycle. In time the carbon became graphitic in nature and could not be burned out even with oxygen.

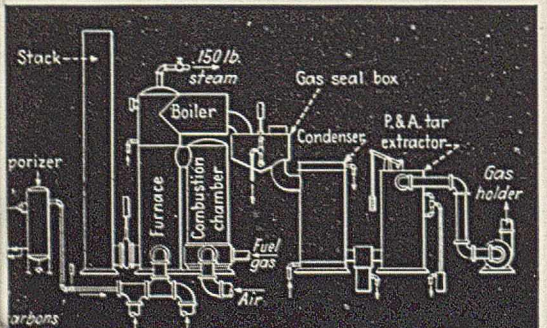
As a result of the extensive work on tube cracking, a large amount of experience was gained on optimum temperatures, contact times, rates of heat transfer with carborundum and heat absorption by the refractory by convection and radiation, so that a satisfactory solution could be worked out for the design of a regenerative furnace. Accordingly, a semi-works furnace was constructed with carborundum brick work laid so as to present vertical, uninterrupted slots very narrow in width. The slots were bounded by carborundum of sufficient thickness to furnish the necessary heat storing capacity and yet thin enough to prevent spalling from heat shock.

At a selected optimum cracking temperature and contact time, the variables concerned in the solution of the problem were the surface and heat capacity of the carborundum, in the cracking zone, and the volume of the gas passage. For a given rate of charging stock — hydrocarbon-steam mixture—the relationship between the dimensions or parameters was found to be very critical if optimum cracking results were to be obtained.

Once the relationship was established, the length of the cracking period was fixed. The complete cycle was quite definitely set at 1½ min. cracking and 3 min. heating times. Although it is desirable to have the cracking and heating periods as long as possible, the upper limit is governed by the maximum thickness of the refractory, bounding the gas passages, which will conduct the heat to and from the surface at the high rates employed without spalling.

It might be noted that carborundum is the only commercially available refractory which meets the drastic requirements of high heat conductivity, coupled with a satisfactory coefficient of thermal expansion and physical strength. Under actual cracking conditions an average heat liberation from the surface of the

Fig. 3—Complete cracking unit assemblage for a commercial plant



carborundum averaged 50 B.t.u. per sq.ft., in thickness, deg. F., hr., for the entire length of the gas passage. We were, therefore, withdrawing heat to the cracking mixture at a rate approaching the conductivity of carborundum itself which is about 100 B.t.u. per sq.ft., in. thickness, deg. F., hr. Radiation was playing an important role, particularly in the hot zone, in attaining the high heat transfer coefficient to the gaseous mixture traversing the channels.

From the above considerations, it is quite apparent that no other refractory than carborundum could serve. Among commercial refractories, magnesite and zirconia approach the nearest to carborundum with about one-fourth the heat conductivity, but they would be impractical to use since the tiles would have to be extremely thin and the cracking cycle of very short duration. If the thickness were the same as in the case of carborundum, conduction within the body of the refractory would be slower than the gases in the two parts of the cycle were adding and withdrawing heat at the surface and as a consequence severe spalling would result.

The development of the regenerative furnace thus involved satisfying of a great many requirements as regards properties of the refractory, temperature, contact time, heat capacity, and transfer and pressure drop within the cracking zone. A satisfactory solution was found and the cracking results obtained with the hydrocarbons equalled in every respect those in laboratory and semi-works tube cracking. An example is given in the following table on the cracking of butane.

	After 15 Sec.	After 90 Sec.	Average Entire Cycle
Carbon Dioxide.	1.6	0.8	1.1
Acetylene	14.1	11.2	12.3
Ethylene	16.5	23.0	17.6
Benzene	0.5	0.6	0.6
Oxygen	0.2	0.2	0.3
Hydrogen	39.4	33.2	38.0
Carbon Monoxide	3.3	1.2	1.7
Methane	22.2	27.4	26.4
Ethane	—	1.0	0.6
Nitrogen	1.5	1.4	1.4

The accompanying illustration, (p. 81), shows the semi-works regenerative furnace and closely connected with it the gas seal box type of quencher. Fig. 3 is a drawing showing the complete cracking unit assemblage as required for a commercial plant. It will be noted that a boiler is provided for generating sufficient steam to furnish the power for compressing the cracked gases for the absorption unit. With steam-driven compressors operating on a 5-lb. exhaust, the requisite amount of steam is available for diluent in the cracking operation. For a continuous supply of cracked gas and steady operation of auxiliary blowers and exhausters three furnaces are required. Automatic time cycle controllers to actuate the valves for process gas, steam, fuel and combustion air are of the same type as in water gas practice. When combined with the automatic flow controls of the various feeds, the operation of the units becomes almost entirely automatic.

The regenerative furnaces for acetylene cracking are surprisingly small in size, since they operate at a tremendously high rate of heat absorption and withdrawal. They possess an added advantage in that there is no build up of carbon, it being completely burned out during each heating portion of the cycle. The carborundum in the high temperature zone is subjected to a much lower temperature than in the case of tube cracking which leads to greater refractory life.

ADAPTABILITY

As has been indicated, the thermal process can be operated in a single pass manner so as to produce both acetylene and ethylene or by recirculation of the latter to produce only acetylene. In both cases a gas separation system is desirable since it is not as economical to convert a dilute gas chemically.

One of the more important advantages over olefin cracking, if ethylene is desired, is that it can be operated so that there are no propylene or higher olefins produced. This avoids the necessity for an expensive low temperature liquefaction system to separate the higher olefins from ethylene. An additional feature is that the acetylene is completely removed from the ethylene which is desirable when certain types of chemical conversions are to be carried out.

Fig. 4 is a flow diagram showing operation with recirculation of ethylene to yield a concentrated acetylene as the sole product of the cracking to be removed. As pointed out previously, this operation substantially doubles the yield of acetylene since in effect the recycled ethylene is converted almost quantitatively into acetylene. The heat and steam balance of the system is also indicated—the hydrogen, methane and carbon monoxide furnish the heat for the furnace; the generation of high pressure steam from the sensible heat of the cracked gas supplies the power for compression of the same gas and the low pressure steam serves for diluent in the cracking process. Thus

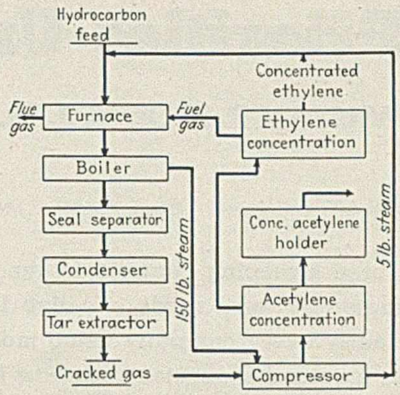


Fig. 4—Flow diagram of cracking operation with recirculation of ethylene

the energy requirements for the production of acetylene by high temperature cracking are supplied by the byproducts of the process and are included in the cost of the hydrocarbon charging stock.

Another no less important advantage of producing this most important building block for organic syntheses by thermal cracking is that no special metals are required for the construction of the plant. Ordinary steel and cast iron are satisfactory, since no corrosive conditions are encountered in any part of the operation.

The writer wishes to acknowledge the contributions to this work of Mr. Robert G. Wulff and many members of the Research and Development Division of the Tennessee Eastman Corp.

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Priorities Undergo Important Changes

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Chem. & Met. INTERPRETATION

Three sweeping changes in the priorities system affecting strategic materials were made effective July 1: (1) First and most important, nearly every company using more than $5,000 worth of basic metals in a calendar quarter must now file an application under the Production Requirements Plan showing actual consumption, inventories and future requirements. PRP supersedes all other priority instruments in the field it covers. (2) All orders placed after July 1 and all previously placed orders calling for delivery after July 31 must now carry the explanatory symbols of the new Allocation Classification Systems. This is the so-called "End-Use" method of designating industrial essentiality in the war effort and is described in detail in the accompanying article. (3) The form of applying and extending all preference ratings has now been made uniform to simplify future procedures. To assist our readers in understanding and applying the new End-Use classifications, the author of "Preference Ratings are Up to You" (Chem. & Met. Oct. 1941, pp 86-91) has prepared this interpretation.—*Editors.*

No matter what you order or where you order it, your order is no longer acceptable by your supplier unless it carries a definite designation of end use. Moreover, *all* orders now in the hands of your suppliers for delivery after July 31st must be classified by you as to end use, before they can be shipped. Therefore, it will be necessary for all chemical and related producers to understand the implications of WPB Priorities Regulation No. 10 which makes this end-use plan mandatory.

It is really not as complicated as it might seem. To get at the crux of the situation, most producers of chemicals will utilize the symbol: 8.20 to indicate that the end use of the materials, equipment, supplies and other things they are ordering is in the chemical field. This symbol goes on all orders placed by the chemical company, even though certain items to be ordered may have been identified with other end uses either by end-use symbols on orders from customers of the chemical company, or by preference ratings indicating such other end uses.

In other words, you will pay no attention to end-use symbols provided on orders to you by your customers, but hold to this symbol 8.20 (or the symbol designated by Priorities Regulation No. 10 for your industrial group) on all orders you place. Symbol 8.20 includes the production or processing of all chemicals such as chlorine, alcohol, and sulphur and includes paint, lacquer, plastics, synthetic rubber, etc. A detailed alphabetical list of chemical and related products, and the end use symbols assigned under Priorities Regulation No. 10 is shown in Table I. There is also included in Table II a list of various industrial and chemical equipment and machinery, with the end use symbol assigned to each.

You may find that your particular products will call for some other end-use symbol than 8.20 and, of course, you may be faced with the problem of a diversified group of products which might call for a number of different end-use symbols. If, however, the major portion of your production falls into a single symbol class such as 8.10, 8.20 and 8.90, you can use the symbol 8.00 to cover all such production.

In those comparatively rare cases where end-use symbols cover more than one class, you are required to utilize the symbols for each of your products with different class symbols the volume of which exceeds 5 percent of your total volume.

However, if you are engaged in sub-contracting, involving materials radically different than those in your regular line, it would be advisable to utilize the alphabetical guide in Priorities Regulation No. 10 to classify such items as directed there.

In addition to the end-use symbols discussed above, there is another group of symbols which must also appear on each order. These supply the W.P.B. with information as to whether the orders are placed for the Army, the Navy, Lend-Lease, Domestic Purchases or other Foreign Purchases besides Lend-Lease. A series of five "designation" symbols are set up for this purpose. *USA* represents the Army; *USN*, the Navy, including the Maritime commission; *LL*, Lend-Lease; *FP*, other Foreign Purchases; and *DP*, Domestic Purchases.

As the system is laid out, most of this last group of "designation" symbols will originate with your customer or customer's customers. In other words, if the Army has ordered anything from a supplier who in turn orders something in connection with that order from another supplier who comes to you, it is mandatory that the symbol *USA* shall be passed on in each case. The same applies to each of the other symbols in appropriate cases.

So when any such order comes to you with any one of these "designation" symbols, you will in turn pass it on in connection with any order you make for supplies which are needed for the order you have received with this symbol.

However, you must not pass on the end-use symbol but instead use the one you are directed to use in Priorities Regulation No. 10, as indicated in the lists shown in Tables I, II and III.

This is true in practically all cases, particularly in the chemical and metallurgical fields. There are a few industries where the order specifically instructs the use of the end-use symbol obtained from customers. These are listed in Table III, and are practically all producers of machinery or equipment.

In using these symbols the five "designation" symbols are to appear first on the order, i.e., *USA, USN, LL, DP* or *FP*, followed by the appropriate end-use symbol. Thus, the order you issue where you have obtained a *USA* "designation" symbol will show "*USA-8.20* to indicate that you are a chemical manufacturer who needs the product ordered to fill an order which will ultimately be used by the U. S. Army.

But where you are ordering material on which a passed-on "designation" symbol is not involved because you are ordering in quantity for anticipated needs, or because you have no way of relating your order to any "designation" symbol, then you will use the *DP* symbol.

Of course, if you are working on a direct Army contract and are the prime contractor, you will be authorized to use the symbol on orders to your suppliers. The same applies to both Lend-Lease and U. S. Navy contracts.

Remember, however, that even in such cases, you will utilize the end-use symbol called for by Priorities Regulation No. 10, even though the material you make goes directly into a product used by the Army or the Navy.

Note also that you use the end-use symbol *applying to your industry for operating, maintenance and repair supplies* and do *not* use the class 22 symbol designated for *manufacturers* of operating, building, repair and maintenance supplies.

You will find, however, that Priorities Regulation No. 10 specifies that where you function as a prime contractor and are ordering materials for a new building or for a building operation resulting from plant expansion, you will not use your regular industry coding, but instead will use the code 21.10. Otherwise, use your industry end-use symbol, even for such building supplies. Ordinarily your contractor will issue such orders and use symbol 21.10.

This applies to all industrial buildings except those that are Government owned and producing war goods in which case the class 7 symbol should be used.

The purpose of this new end-use coding of orders is the obtaining of data which will insure allocation of scarce materials on a basis compatible with war demands. You will find that once the system is well established, the data you obtain will be of great value to you in presenting your case to the W.P.B. on form PD-25-A under the production requirements plan in particular, and in fact, on any other priorities application forms.

The PD-25-A form to be used for applications under the production requirements plan for the fourth quarter of 1942 will be set up to utilize the data obtained by this end-use and "designation" symbol system.

In actual practice, since the responsibility of placing the symbol on the order is in the hands of the buyer, each seller should obtain adequate data for end-use classification by keeping a suitable record of the orders he receives. (You cannot put these symbols on orders from your customers. Only they can do this.)

It is expected that the system will not work perfectly at first but in view of its simplicity and its mandatory nature, it should not take long for everyone who has passed through the priorities mill to use it readily.

As a matter of fact, this system should be welcomed by industry as a whole because it will enable a great many firms who have had difficulty in establishing the full extent of their relation to essential war efforts to show how extensively they are thus identified. Remember that all ratings were not necessarily *always* extended, since any supplier who could deliver a needed article or material without need for extending the preference rating he had received could break the chain which might otherwise have identified the last supplier in a long, long chain with essential war work.

Table I.—Chemical and Kindred Products Listed According to End-Use Classification

	End-Use Symbol
Abrasives	22.00
Acetone	8.20
Acids	8.20
Alum	8.20
Ammunition for private use	18.00
Artificial leather	8.90
Asbestos	8.90
Asphalt	8.90
Baking powder and yeast	14.00
Beet sugar	14.00
Blast-furnace products	8.10
Bluing	8.20
Bone black, carbon black, lamp black	8.20
Brick and hollow structural tile	8.90
Buttons	15.00
Camphor	8.20
Candles	23.00
Cane sugar	14.00
Carbon paper	19.00
Cellophane	8.20
Cement	8.90
Chewing gum	14.00
China firing and decorating	16.00
Chlorine	8.20
Cleaning and polishing preparations	22.00
Coal-tar products	8.20
Coke	9.30
Colors and pigments	8.20
Compressed and liquefied gasses (except petroleum)	8.20
Concrete products	8.90
Cooking and other edible fats and oils	14.00
Copper refineries, operation of	8.10
Corn syrup, sugar, oil and starch	14.00
Cosmetics	12.20
Cottonseed oil	8.20
Dextrine and dextrose	8.20
Drugs and medicines	12.20
Dyeing and finishing textiles	8.90
Dyestuffs, natural and artificial	8.20
Essential oils	8.20
Ether	8.20
Feeds for animals and fowls	13.00
Fertilizers	13.00
Fireworks	18.00
Fish and marine oils	8.20
Flavorings	14.00
Floor and wall tile	8.90
Fungicides	13.00
Furs, dressing and dyeing	8.90
Gas, natural and manufactured	9.40
Gasoline	9.20
Gelatine	8.20
Glue and gelatine	8.20
Grease and tallow (except lubricating)	8.20
Gum naval stores	8.20
Gypsum products	8.90
Insecticides and fungicides	13.00
Insulation and mineral wool	8.90
Knitted cloth	8.90
Lead and lead foils	8.10
Leather, tanning	8.90
Lime	8.90
Liquors, distilled	14.00
Malt	14.00
Malt liquors	14.00
Manufactured gas	9.40
Medicines	12.20
Mining operations	8.10
Natural gas	9.40
Natural graphite	8.90
Nitrates	8.20
Non-alcoholic beverages	14.00
Non-clay refractories	8.90
Oil (petroleum)	9.20
Oil cloth	8.90
Oleomargerine	14.00
Paints, varnishes, lacquers	8.20
Paper and paper-board operations	8.90
Perfumes and cosmetics	12.20
Petroleum	9.20
Phosphorus	8.20
Plastic raw materials	8.20
Printing ink	17.10
Processed waste and recovered wool fibers	8.90
Pulp mill operations	8.90
Rayon yarn, thread and fabrics	8.90
Salt	8.20
Sand	8.90
Shellac	8.20
Smelters, operation of	8.10
Soap	12.20
Sodium compounds	8.20
Soybean oil	8.20
Sulphur	8.20
Tanning materials	8.20
Tin and other foils	8.10
Tobacco and snuff	14.00
Toilet preparations	12.20
Turpentine and rosin	8.20
Varnishes	8.20
Vegetable oils	8.20
Vinegar and cider	14.00
Wallboard and wall plaster	8.90
Wallpaper	16.00
Wines	14.00
Writing ink	19.00

Table II.—Processing Equipment and Industrial Machinery Given Classification 20.20

Bake Ovens for Commercial Use
Baking Machinery
Beet-sugar machinery
Bottling machinery
Brewhouse machinery
Cane sugar machinery
Canning machinery
Cement mixers
Chemical machinery and equipment
Clay working machinery
Combing machinery (textile)
Leather working machinery
Measuring instruments
Mining machinery and equipment
Paint-making machinery
Paper-mill and paper products machinery
Pasteurizers
Scales and balances
Special industrial machinery
Spinning machines
Tobacco machinery
Textile machinery
Vibrators, industrial

Table III.—Industrial Equipment on which the End Use Obtained from Customers Must be Transmitted

Air compressors
Barrels, drums, kegs
Batteries, storage and primary
Bearings
Bolts, nuts, washers
Conduit and fittings
Cooperages, barrels, kegs, tubs
Diesel engines
Electric motors
Electric outlets, plugs, sockets, switches
Fiber cans and tubes
Furnaces, industrial
Gaskets
Gears
Generators
Internal combustion engines
Mechanical furnace stokers
Oil burners, industrial
Power boilers
Sinks
Valves

Protective Measures for Aluminum Equipment

H. J. FAHRNEY and R. B. MEARS *Aluminum Company of America and Aluminum Research Laboratories Respectively*

Chem. & Met. INTERPRETATION

Now that the federal government is allocating almost all aluminum as soon as it is produced to the airplane industry, it behooves the process industries to make every effort to protect their aluminum equipment so as to reduce the necessity for replacement. The authors suggest several measures that have proved beneficial and therefore should be considered if corrosion occurs.—*Editors.*

Aluminum and its alloys are widely used in constructing certain types of equipment for the process industries. For most of these applications, little or no reaction occurs between the substances being processed and the aluminum. In other cases, some reaction may occur. In cases of the latter type, it is often possible to extend the life of equipment appreciably by suitable protective measures. At the present time, nearly all available aluminum is needed for military purposes, so that it becomes imperative to utilize any protective measures which will reduce the need for replacement of equipment.

Several protective measures which have proved beneficial are available. These methods of protection include:

1. Cathodic protection
2. Protective coatings
3. Chemical inhibitors
4. Periodic cleaning

Each of these methods has special fields of usefulness. Cathodic protection is particularly suitable for preventing attack by unrecirculated waters and by nearly neutral or slightly acid salt solutions. The liquids must have a relatively high conductivity and only areas of the metal exposed in contact with the liquid can be cathodically protected. In cases where it is applicable, cathodic protection is usually the cheapest and most effective method of preventing attack.

Chemical inhibitors are particularly useful in recirculated waters or in cases where the same material is to be stored for relatively long periods of time in the equipment under consideration. As with cathodic protection, only the metal areas below the liquid level are normally protected by inhibitors.

Protection against more severe conditions, such as the stronger acids, can best be obtained by coatings. These can be applied most readily to new equipment or to units which can be easily handled.

Periodic cleaning has proved most useful in cases where solid products settle out on the metal surface and adhere tenaciously to it. It is generally of little use where the liquids being processed uniformly dissolve the metal surfaces which they contact.

CATHODIC PROTECTION

The electrochemical theory of cathodic protection has been discussed in several recent papers (R. B. Mears and R. H. Brown—*Trans. Electrochem. Soc.* Vol. 74, p. 519, 1938. R. H. Brown and R. B. Mears—*Trans. Electrochem. Soc.* Vol. 80, 1942), and it is assumed that the reader is familiar with the principles of this method.

Protection of aluminum equipment by means of zinc or zinc-bearing aluminum alloy attachments has been successfully employed in a number of installations (R. B. Mears and H. J. Fahrney—*Trans. Amer. Inst. Chem. Eng.* Vol. 37, p. 911, 1941). In most of these cases protection against corrosive waters has been required although this method has been used with equal success to prevent attack by weak acids and brines.

Brief descriptions of several of these installations will illustrate typical conditions under which cathodic protection is effective and the manner in which protective strips are applied.

Jacketed crystallizing tanks of aluminum were being attacked by unrecirculated cooling water. This water was extremely high in chlorides and total solids. The rate of attack at the air-water interface on the outer tank wall was such as to necessitate repair after as little as nine months of service, and replacement of the tank after two or three years of service. Zinc strips were attached to the jacket walls of the crystallizers, including several new units, in April, 1939. Examaination in March, 1942, revealed no perceptible corrosion on the units which were new when the zinc strips were installed. It was also found that the corrosion which had started in the older units had been completely arrested. The zinc attachments of several tanks were almost entirely consumed after this three-year period of use and must soon be replaced. If the life of zinc attachments of the size originally installed is assumed to be three years, it can be calculated that the cost of protecting these tanks is approximately \$5 per year. The cost of the tanks themselves was about \$1,000. Thus, the cost of protection, in this case, was about 0.5 percent per year.

Attack by cooling waters used in condensers is common. In the case of a certain condenser with an insulated shell, aluminum heads, and aluminum tubes, acetic acid is condensed inside the tubes and caused no serious attack, however, the unrecirculated cooling water attacked the outside surface of the tubes. This attack was probably accelerated by galvanic action between the aluminum tubes and the steel shell. After the tubes had been replaced several times at relatively short intervals, zinc strips were attached to the shell in the manner indicated in the picture. While it has not been possible to examine the tubes since the zinc strips were installed, the fact that the condenser has operated without tube replacements for a period several times longer than the former interval between tube replacements indicates that cathodic protection has been effective.

Experience in these installations, and in others, seems to justify the conclusion that this method of protection will adequately prevent attack of aluminum alloys by most waters.

While the use of cathodic protection to prevent attack by brines or weak acids has been limited, it has proved effective in several cases. In one case there are two insulated aluminum tanks in which a hot emulsion of wood gum and brine is permitted to separate. The brine contains acetic and formic acids, as well as heavy metal compounds. Attack of the tank bottom was quite rapid and replacement of the bottom was formerly necessary after about one year. Zinc strips were installed in the bottoms of the tanks in May, 1940. When examined in January, 1942, it was found that no further attack had occurred since strips were installed.

In laboratory tests, the ability of zinc to effectively prevent attack of aluminum by a sludge consisting of brine and iron sulphide in solutions saturated either with air or hydrogen sulphide has been demonstrated. This suggests the possibility of protecting crude oil storage tanks and petroleum refinery equipment by this method.

While experience indicates that cathodic protection is effective in a wide variety of waters and in some brines and weak acids, it does have certain limitations. It is essential, of course, that zinc be anodic to the aluminum alloy in the particular solution involved. Zinc is usually anodic to aluminum in neutral or acid solutions and sometimes in weakly alkaline solutions. In strongly alkaline solutions however, aluminum becomes anodic to zinc, and this method of protection cannot be used. There is also some evidence that aluminum may become anodic to zinc at elevated temperatures. For these reasons, a laboratory determination of the potential between zinc and aluminum in the solutions and at the temperatures involved should be made before zinc attachments are installed.

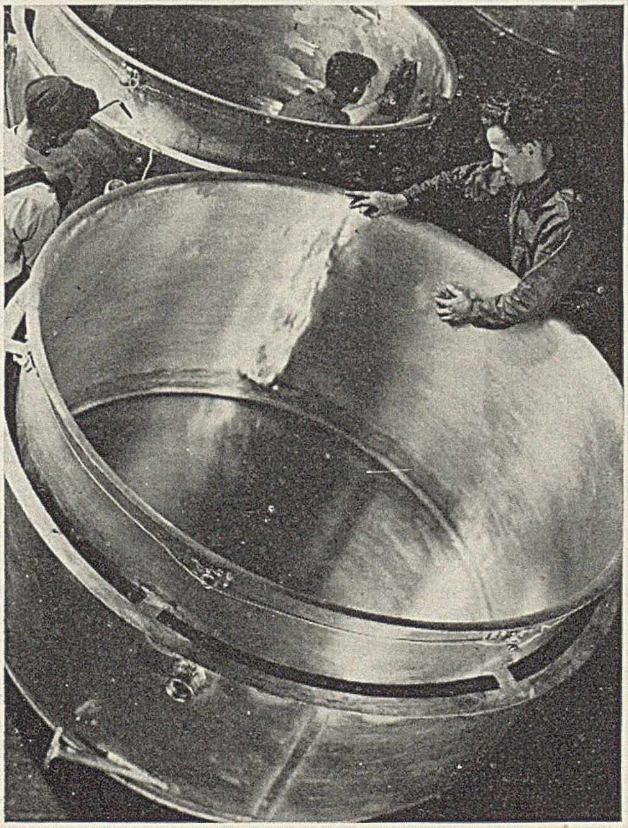
It has not yet been possible to reduce the selection of sizes and the distribution of the zinc strips to an exact science. The protective influence of the zinc usually extends for at least 18 in. from it and, in some cases, protection is afforded at distances several times as great. It is necessary, however, to rely upon experience and judgment in determining the distribution of the zinc strips.

CHEMICAL INHIBITORS

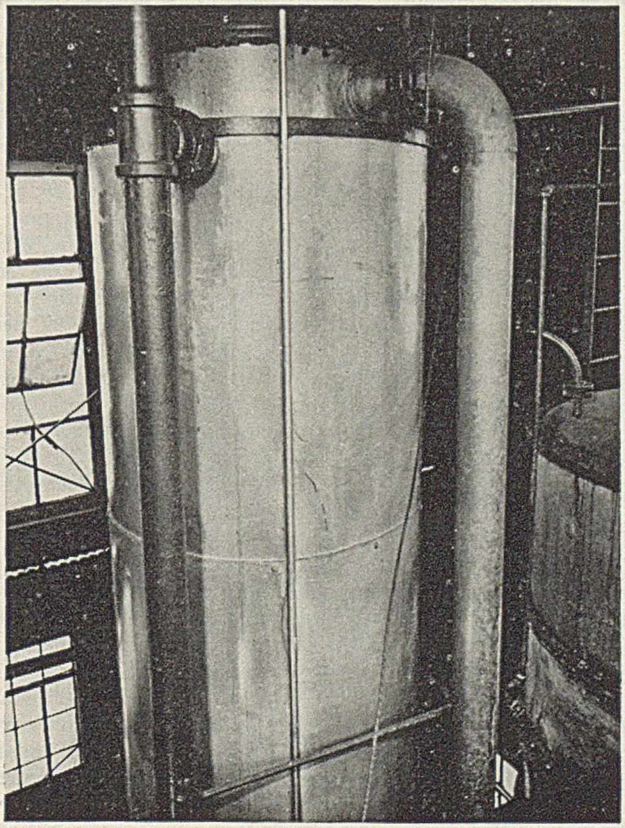
It is sometimes desirable to use aluminum or its alloys in contact with corrosive waters. Thus, for example, a jacketed processing vessel is required. Aluminum or one of its alloys may be ideally suited for contact with the product being treated. However, the water used for cooling or heating purposes in the jacket may cause some attack on the aluminum. If this liquid is recirculated it is often feasible to treat it with a chemical inhibitor in order to render it non-corrosive. Many chemicals possess inhibitive properties. Up to the present, however, only three types of substances have been widely used for this purpose. These are the chromates, the silicates, and the soluble oils. A few examples will be given to illustrate the use of these inhibitors.

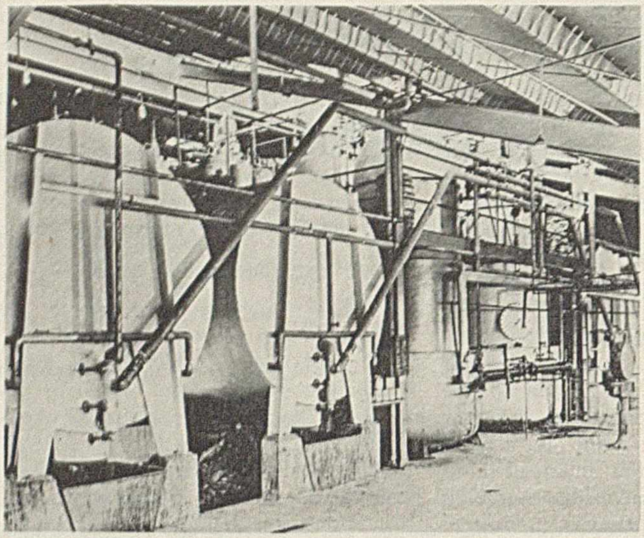
A battery of large, jacketed alumi-

Jacketed crystallizing tanks of aluminum were being attacked by unrecirculated cooling water containing chlorides and solids. Zinc strips attached to jacket walls protect the tank

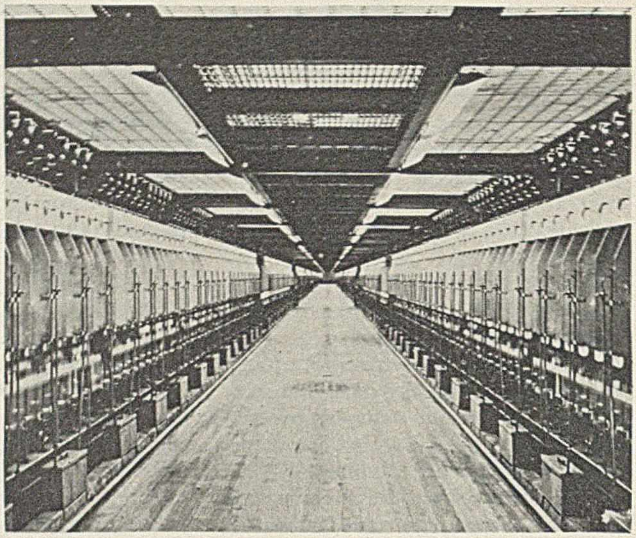


Condenser has operated without tube replacements for a period several times longer than the former interval between tube replacements indicating cathodic protection has been effective





These insulated tanks are used for processing hot rosin-brine emulsions. Cathodic protection of the tank bottoms by zinc attachments has proved highly effective in prolonging the useful life of the aluminum tanks



Rows of continuous spinning and processing machines at the Industrial Rayon Corp., Painesville, Ohio. Aluminum dryer reels, heated with inhibited hot water, are located inside each of the individual dryer boxes

num coolers was installed in order to chill a liquid product. The cooling liquid which circulated through the jackets consisted of 20 percent water and 80 percent ethyl alcohol. After two years of use, it was found that appreciable attack of the jacket walls had occurred. Laboratory tests were made which indicated that the addition of ⅛ ounce per gallon (1,000 p.p.m.) of potassium dichromate to the cooling liquid rendered it non-corrosive to aluminum. On the basis of these tests, a concentration of ⅛ ounce per gallon of potassium dichromate was maintained in the cooling liquid. Examination after two more years of service indicated that this addition had served to completely or almost completely inhibit further attack.

In another installation, hot recirculated water was passed through aluminum drying reels. This water proved to be corrosive, so that pits of appreciable depth developed in a few months. Treatment of the water with about one ounce per gallon of a saponified, naphthenic-base oil was found to inhibit attack. Soluble oil was selected as the inhibitor in this case since, in hot solutions, particularly if appreciable concentrations of chlorides are present, chromates are not satisfactory corrosion inhibitors. (L. W. Kempf and N. W. Daugherty—Reports to Aluminum Assoc., July and November, 1938. See also *Automotive Industries,* Vol. *81,* p. 156, 1939.)

The inhibiting action of silicates was pointed out by Seligman and Williams (R. Seligman and P. Williams—*Jl. Inst. Metals,* Vol. *28,* p. 297, 1922) some years ago. At the present time, silicates are of most value for inhibiting alkaline detergents, tooth paste, shaving cream, and the like, where the toxicity of chromates would be undesirable. since silicates are not as powerful inhibitors as the chromates, they are not normally used unless some of the other properties of the chromates would be objectionable. Silicates with high SiO_2 to Na_2O ratios (two or above) are better inhibitors than are the more alkaline silicates.

In solutions of the mineral acids, chromates may serve to stimulate attack, instead of retarding it. (L. J. Benson and R. B. Mears—*Chem. & Met.,* Vol. *49,* p. 88, 1942.) However, certain organic compounds, such as acridine and dibenzyl sulphide, have proved to be effective inhibitors in such solutions. Inhibitor efficiencies of up to 97 percent have been obtained in dilute hydrochloric or phosphoric acid solutions. (Unpublished work at the Aluminum Research Laboratories by G. G. Eldredge.) In special cases, other inhibitors have also proved useful.

PROTECTIVE COATINGS

The use of organic coatings to prevent attack of aluminum has been common in certain industries. In the rayon industry, such coatings are widely used on spools and buckets, while in the foods and drugs industries coatings are applied to collapsible tubes and foil wrappers. Many aluminum structures, including some of those exposed to sea water, are painted. (For suitable methods see R. I. Wray—*Aviation,* October, 1941.)

A large number of coating materials are available, and no attempt will be made to discuss their characteristics and fields of usefulness in detail. The most generally useful coatings for applications requiring the maximum chemical resistance and mechanical durability are the baked phenolic resins. These have been widely used in applications involving severe chemical exposure.

Recently, because of the difficulty of replacing aluminum equipment, these coatings have been applied to parts for which protection was not previously considered necessary, in order to extend the service life of the present equipment. Typical of these cases is a corrugated aluminum cylinder which was being slowly attacked by the dilute sulphuric acid with which it comes into contact during use. Six coats of phenolic resin are now being applied to these parts. The coating has proved very satisfactory in preventing attack.

The life of such coatings depends largely on the amount of mechanical abuse to which they are subjected. Rayon spools and buckets which are frequently and roughly handled may require recoating after only 15 or 18 months of service. In other cases, such as piping, where no mechanical abuse is involved, the life of the coating is indefinite.

The use of these coatings on aluminum has been limited largely to rather small pieces of equipment, which can be handled readily in paint shops with ordinary facilities. They have, however, been applied to large tanks and other equipment of steel and there appears to be no reason why the methods of application developed for large steel tanks would not be equally effective in the case of aluminum equipment. Several companies specialize in the application of coatings to large equipment which is already installed.

The maximum temperature to which baked phenolic resins may be exposed continuously is about 350 or 375 deg. F. Their use in contact with strong oxidizing agents, such as nitric acid, is not recommended. They are, however, resistant to other inorganic and organic acids and to weak and moderately strong alkalis.

In the case of equipment which is already corroded, particular attention must be given the problem of removing completely all corrosion products, either chemically or mechanically. Proper cleaning and preparation of the surface is of extreme importance as the degree of adhesion of the coating is determined almost entirely by the condition of the surface.

It is believed that this method of protecting existing equipment will be most useful in cases in which slow-to-moderate attack of the uniform solution type is occurring. This type of attack produces a surface which can be readily prepared for coating. Attack by pitting may produce a surface which is difficult to clean and coat.

CLEANING METHODS

Periodic cleaning of aluminum equipment will sometimes greatly extend its useful life. Cleaners which have proved useful can be divided into two general classes: surface renewing cleaners and safe cleaners.

Surface renewing cleaners are those which, as a result of either physical or chemical action, remove a thin layer of the exposed metal surface along with the soil or accumulated residue. Steel wool and soap is an example of a surface renewing cleaner which depends on its abrasiveness for its beneficial action. The effectiveness of the periodic use of steel wool and soap has been described in a previous publication. (J. R. Akers and R. B. Mears—*Soap and Sanitary Chemicals*, April, 1941.) A synthetic tap water containing dissolved heavy metal salts and chlorides was boiled in aluminum alloy (3S) pans for eight hours a day. The water was poured out of one pan and the pan was dried but not cleaned every day. Another pan received similar treatment except that it was cleaned with steel wool and soap after each four hours of boiling. The uncleaned pan became perforated after boiling for 324 hours while the pan which was cleaned with steel wool and soap was in excellent condition after boiling for 1,000 hours.

While periodic cleaning with steel wool may be extremely beneficial, it is often impractical for equipment of substantial size. Suitable chemical solutions can be substituted in such cases. A series of large, aluminum vessels were being used for the batch steaming of a solid product. After each period of use, the vessels were washed out but were not cleaned in any other manner. Chlorides and both iron and copper salts were present in the wet product. Therefore, in the course of time, the interiors of the processing vessels became roughened by spots of localized attack.

Laboratory tests, simulating the conditions of service as closely as possible, indicated that periodic cleaning of the aluminum vessels with a warm solution containing 47 grams of tartaric acid and 3 grams of sodium fluoride per liter was beneficial. In fact, periodic cleaning with this solution reduced the rate of attack to less than one-third that which occurred in the absence of such cleaning.

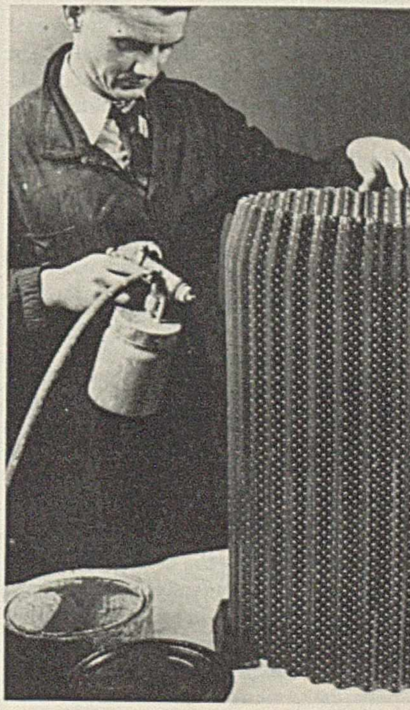
Subsequently, two new processing vessels were installed. One was cleaned periodically with the tartaric-fluoride solution, while the other was simply rinsed out with warm water as was the usual custom. The vessels were examined after being used for 15 months, during which period the one vessel was cleaned seven times. The periodic cleaning had been of definite benefit in preventing the development of localized attack.

The beneficial effect resulting from the periodic use of surface renewing cleaners can be attributed to at least three fundamental causes. Adhering masses of material are removed from the metal surface. Such masses can set up potential differences which cause local attack—U. R. Evans—Metallic Corrosion, Passivity and Protection, p. 508, 1937, Edward Arnold & Co. (R. B. Mears and R. H. Brown—*Ind. & Eng. Chem.* Vol. *33*, p. 1001, 1941.) If heavy metal salts are present in the liquids contacting the surface of the aluminum, deposition of these metals will often occur on the aluminum surface. Heavy metal deposits thus formed will stimulate the attack on the aluminum by galvanic action. Finally, it has been demonstrated (R. B. Mears and U. R. Evans—*Trans. Faraday Soc.* Vol. *30*, p. 423, 1934; Vol. *31*, p. 538, 1935. R. B. Mears and R. H. Brown—*Ind. & Eng. Chem.* Vol. *29*, p. 1089, 1937.) that increasing the area of the metal surface which is attacked will result in a decrease in the intensity of attack. Surface renewing cleaners will remove the heavy metal deposits and also increase the area of the aluminum surface which is exposed to attack.

In contrast to the three separate functions of surface renewing cleaners, safe cleaners have only the one function. They will remove adhering masses from the aluminum surface. This may be extremely important in specific cases, although such cleaners are not of as general usefulness as are the surface renewing type.

Many types of aluminum equipment require no special servicing in order to have an indefinitely long life. In other cases, aluminum equipment may resist attack sufficiently long to be the most economical type to use, but since during the present emergency replacement is difficult or impossible, the application of special protective measures may be warranted. The methods described in the present paper include cathodic protection, protective coatings, chemical inhibitors, and periodic cleaning. In certain cases, two or more of these protective measures can be combined with advantage.

Corrugated aluminum cylinder protected from the action of sulphuric acid by a baked phenolic resin coating



Prolonging Life of Centrifugal Pumps

A. T. NIELSEN *Application Engineer, Worthington Pump & Machinery Corp., Harrison, N. J.*

Chem. & Met. INTERPRETATION

Now that new equipment and even repair parts are becoming almost unobtainable in some industries it is essential that careful attention be given to maintenance. The author gives maintenance suggestions that have been found of value for pumps.—*Editors.*

It is becoming daily more important that the maintenance of process pumps be given careful consideration and study, as for some industries new machines and even repair parts are becoming almost unobtainable due to the materials shortage. "Doing with what we have" has become the order of the day to the process industry not directly expanding for war production and, "keeping them rolling" applies just as much to process pumps in these industries as it does to any other piece of war equipment. It is the purpose of this paper to outline the basic fundamentals underlying the maintenance of pumping equipment and its field repair. The two go hand-in-hand, and careful attention to the former will, in many cases, limit and in some case obviate entirely the necessity for attention to the latter. Proper maintenance will be discussed first. Since it is obvious that pumps in certain applications will require repairs, regardless of the amount of maintenance. Field repairs with suggestions as to the proper method of accomplishment will be discussed later.

The first and foremost maintenance feature that should be followed in a modern process plant is the keeping of proper records. A suggested manner of doing this is by means of card index file in which the various pumps are catalogued under their plant number and given a separate card. This card should contain at the top the following information: the plant pump number, the size, manufacturer's name and style, the serial number, the date installed and other pertinent information which will assist in the rapid location of repair part lists, manufacturer's part numbers, etc. The remainder of the card may be divided into a number of columns, the first entitled "Repair Date," second, "Part Affected," third "Remarks," and fourth "Cost". Care should be exercised in entering on the proper cards each and every maintenance or repair operation performed on the unit in question as within a short time a certain pattern of maintenance becomes apparent when such a card file is examined, and the frequency of maintenance or repair of various units, or groups of units on allied services, will become apparent. From this examination a schedule of maintenance points can be set up as regard such important items as packing, greasing or oiling, painting, gaskets replacement, bearing examination and other more or less frequent maintenance points on the pump or group of pumps; thus it may be found that a unit or group requires packing maintenance approximately once a month, greasing once every two weeks, new gaskets once every six months, and so forth. The plant schedule may then be arranged in such a fashion that the particular equipment may be shut down and thus becomes available to the maintenance men at, or before these times. They may then perform these duties under proper and unhurried conditions, resulting in the continuity of production schedules yet with proper, complete, and thorough maintenance work.

Further, examination of such a card catalogue will guide the operating and maintenance personnel as regards the quantity of repair parts required to be on hand for the units in question. As time progresses, such a card file becomes the history of maintenance, and a complete guide to the maintenance routine required. If it is viewed as a means of anticipating normal maintenance jobs before they are sorely required the index results in a reduction in repair cost, in that the parts in question receive attention before they are spoiled or worn beyond use.

The most important parts of pumping equipment requiring frequent attention and inspection are the rotating and/or reciprocating parts and the stationary parts immediately supporting them. Therefore, the parts requiring this attention on a reciprocating pump are the pistons, valves, valve gears and piston rods. Those requiring such attention on a centrifugal pump are the shaft, bearings, shaft sleeves, impeller and stuffing box. Parts requiring frequent inspection are those between which there is relative motion, such as stuffing boxes and shafts or rods, shafts and bearings, impellers and casings, pistons (rings or packing) and cylinders, and valves and their seats. Frequent and regular inspection of these places should be established, and when made will often lead to the reason for excessive maintenance or repair. When frequently inspected and the progressive deterioration of a part observed the reason for the deterioration will make itself known.

The maintenance suggestions that have been found of value as regards particular parts of pumping equipment will be delineated. However, with regard to a pump proper and its installation, the following points are almost axiomatic.

Care should be taken to assure that no piping strains are transmitted to the pump, and that the pumping mechanism is not subjected to strains in any direction. Another point is the alignment of the driven and driving units. This matter is extremely important in that very often, the couplings may be of such a size that they can readily absorb considerable misalignment and consequent thrust. However, the bearings adjacent to them may not be capable of absorbing the thrust thus transmitted by the coupling, and serious failure of the rotating parts may result. It is of particular importance to check alignments frequently, especially if the equipment is dismantled for inspection. Also, pumping equipment should be so installed as not to be subject to shock regardless of whether it is hydraulic, mechanical or thermal.

Frequent inspection of the bearings should be followed for these are the support points for the rotating or reciprocating members, and failure is often of an insidious nature, being sudden rather than progressive. By inspection is meant the dismantling of the bearing from the machine and a careful mechanical check of its condition. All bearings should be examined for cleanliness and must be scrupulously clean when re-installed; wipers, closures or bearing guards should also be inspected at the same time as the bearing to insure their tightness and ability to keep the bearing free of foreign material. Care should be taken when re-installing bearings to be sure that their clearance does not approach or exceed any running clearances depending on the bearing sets within the pumping unit.

The most important maintenance point on process pumping equipment is the stuffing box, and if one major point is kept in mind, that the box shall be kept clean, cool and lubricated, the operator will have conquered the most important hurdle toward proper maintenance of this point.

The second major point is the proper installation of new packing. Everyone knows how to pack a pump shaft, and the methods are as varied as the claimants to this knowledge. In describing their pet methods these self-ordained experts invariably leave out the most important consideration, which however should be first on their tongues as it is next to godliness. Dirt, grit or foreign matter of any description have no place in a stuffing box—cleanliness in the repacking operation cannot be stressed too much. Packing is generally received in boxes or on spools that are carefully wrapped. It should be kept in these containers and not left open to collect everything that is flying about in the atmosphere. Once a piece of packing is dirty you cannot dust it off! Packing should be handled with clean hands, cut with a clean knife on a clean surface. A piece of newspaper makes an excellent working place to handle packing. Cutting to the proper length is not as easy as it sounds; somewhere near proper length is not good enough, and the best job is done when the packing, cut clean and square, *exactly* meets when wrapped tightly about the shaft of the pump.

The interior of the box should be inspected before packing is inserted to assure that it is clean and free of any dirt, bits of old packing, etc. The individual rings should be installed with care, their joints staggered, and each firmly pressed into place. An excellent device for insuring the proper seating of each ring of packing is a piece of pipe larger in diameter than the shaft, but smaller in this dimension than the stuffing box; and split lengthwise into halves. After each successive ring is inserted into the box, this length of pipe may be fitted about the shaft and moved inward into the box guaranteeing the firm and proper placement of the successive rings in order. If the box in question is equipped with a seal cage, the position of this piece should be checked to be sure that it is directly in connection with the entrance in the stuffing box for the sealing medium.

After the packing has been properly installed as described above, the gland should be pulled up evenly with a wrench until it is tight and snug. The gland nuts should then be backed off until the gland is free and then taken up just finger tight. The stuffing box should then be constantly observed for the next 24 hours or so and each time an excessive leakage is observed a sixth or third of a turn on the gland nuts should be taken. This method will avoid excessive pressure on the packing during this critical portion of its life and the result will be that the lubricant will not melt out of the packing, and no charring (with consequent scoring of the shaft or sleeve) will occur. Proper attention during this "run-in" period pays dividends in the form of greater packing life and enhanced life of the shaft or shaft sleeve.

After this initial period the following remarks may be used as guidance. Stuffing box glands should not run while tight, and stuffing boxes should not be run while warm. It should be kept in mind that the average packing if run while dry, hot and tightly compressed against the shaft, becomes nothing more than a brakeshoe, therefore, this kind of operation should be avoided wherever possible. If other than a clear, non-corrosive liquid is handled by the pump in question (and with such liquids, the stuffing should drip as the fluid pumped becomes the lubricating medium between the packing and the shaft) an independent source of bland fluid should be supplied to

PUMP MAINTENANCE CARD

__________ PUMP NO. __________ MANUFACTURER

__________ SIZE __________ MFGR'S ADDRESS

__________ DATE INSTALLED __________ " SERIAL NO.

__________ LOCATION __________ " STYLE

DATE	PART	REMARKS	COST

the stuffing box to form the lubricating medium between the packing and the shaft. An extention of remarks under this subject will be found in an article entitled "Centrifugal Pumps In Process Use" by A. T. Nielsen, *Chem. & Met.*, p. 90-92, March, 1942.

It is imperative that the rotating shaft of a centrifugal pump run true in the stuffing box. If it is found that it is not possible to hold packing in such a pump for a reasonable length of time, eccentric rotation of the shaft or sleeve in the stuffing box should be suspected and corrected. The average centrifugal process pump uses non-resilient packing which cannot tolerate more than about two thousandths of an inch eccentricity, or out of roundness, at this point.

Impellers in centrifugal pumps are perhaps the most important of the rotating parts from a maintenance and observational standpoint. The maintenance consists of frequent inspection to insure that the impeller is free of obstruction, properly located and in reasonable balance.

COUPLING COVER

Couplings on pumping machinery are most generally selected by the manufacturer and are ample for the power to be transmitted. They are generally rugged and their care is a simple matter. However, for process pumps, it has been found that an important contribution can be made to the maintenance of the coupling if it is covered with a boot of some impervious material. A piece of old inner tube, canvas well impregnated with oil or paint, or some similar sheeting can be tied over the coupling to protect it from corrosive vapors and drips. This often enhances the life of the coupling buffers and other parts considerably and adds very little to dismantling time.

The frame, baseplate, and supporting parts of a pump are as important as the rotating and working parts and should be regularly inspected, washed and painted to prevent deterioration due to corrosion. Care should be taken that stuffing box drips and/or other drips, or washings do not contact these parts for long periods. These drips should be carefully piped away in order that hidden corrosion underneath the frame and baseplate do not proceed to the point that these parts may be rendered useless. In this connection, it is important to state that one of the prime maintenance features in any plant is good housekeeping. Small defects and unwanted operational faults become more apparent when the equipment is clean.

Pistons, liners, valves and stuffing boxes of reciprocating pumps are the parts requiring most frequent inspection. These moving parts all operate in a lineal direction and visual observation should assure that they do so. If they do not, the fault should be corrected as a rod or valve not stroking or lifting lineally concentrates stresses or wear on small portions of itself resulting in rapid failure of the part.

FREQUENT OILING

Oiling and greasing should be done frequently with the proper grades of lubricants and at intervals recommended by the manufacturer of the particular parts.

Field repairs depend more or less on the ingenuity of the maintenance engineer, the material to be repaired, the method, and materials available for repair work. It is important that if a repair is contemplated that inspection reveal the deterioration of the part before it has proceeded to a point where such field repairs are not possible. This applies especially to such parts as impellers on centrifugal pumps. Their state should not be such that the vanes and shrouds are worn or corroded so thin that their original contour cannot be followed and reproduced. Building up such parts by welding, metal spraying or brazing is not excessively difficult. The part should then be ground or filed to approximate its original shape. It is not to be expected that such a part will perform as efficiently or as well as a new part built by the original maker, but many instances of repairs by this means have given good accounts of themselves.

Pump parts often become worn to an inoperative state when better than three-quarters of the base metal is still in existence. Care should be exercised to repair a part with a metal of similar chemical composition in order that galvanic corrosion, when handling even mild electrolytes, will not result from the use of dissimilar metals. Long, slender parts, such as shafts and rods when welded or sprayed should be rigidly supported, and uniformally heated and cooled in order that warping will not take place. They should be carefully checked for concentricity and straightness before reinstallation. For emergency repairs paints and enamels should not be scorned as stop-gap measures for pump interiors, neither should such old standbys as Smooth-on and other repair preparations be scorned.

As regards substitution of materials, there are thousands of pumps in operation today which were originally supplied with bronze trim or were fully bronze fitted for which iron parts may be substituted with little or no change in length of service. Similarly carbon steel (hardened or not as the case may require) will be found excellent as a replacement material for many parts formerly constructed of stainless or chromium steel. These are perhaps the two main substitutions required in pumping equipment and apply of course only where the original materials were not selected for their resistance to a particular corrosive agent in the material handled. It is difficult to make further general statements as regard substitutions for in many cases the physical properties of the original material were taken into account when the part was designed. And although a particular substitute may have chemical characteristics such as to render it an adequate replacement its physical properties may be such that a part made of it might not bear the mechanical stresses imposed upon it in service. Where it is difficult or impossible to obtain a replacement part of the original material, the best procedure is to present the problem to the manufacturer of the equipment with a full statement as to the services the equipment is performing. More likely than not, because of his wide experience with his particular machines he will be able to suggest an obtainable substitute material which will perform with reasonable effectiveness.

EXCESSIVE SPEEDS

As a final suggestion, in these days when production is the cry, pumping equipment should not be driven to its utmost. Nor should manufacturer's speeds or pressures be exceeded since many stresses increase as exponential functions of these variables.

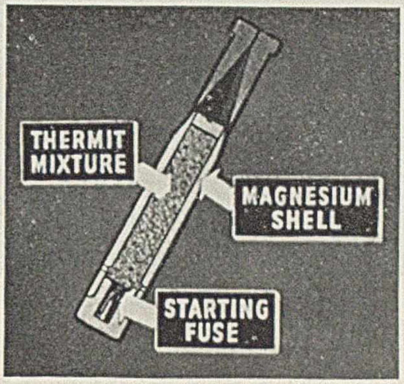
Care and attention, periodic and frequent inspection, should be the motto for the pump user today, and each piece of equipment should be looked upon as being irreplaceable and treated as such. When in doubt about a proposed method of repair, or a new service for a pump, consult the manufacturer. He will be only too glad to give information, because anything you can do today to keep your equipment running without replacement will very likely mean an increased production of important war material in the fabricator's plant.

Thermit—Its Uses in War and Industry

J. H. DEPPLER *Chief Engineer, Metal and Thermit Corporation*

Chem. & Met. INTERPRETATION

The intense heat generated by the thermit reaction—computed to be over 5,000 deg. F.—well serves the ends of both war and peace. The magnesium-thermit incendiary bomb developed by the German, Goldschmidt, during the closing months of the first World War has become the principal article of foreign trade between Germany and England. Mr. Deppler describes this product in detail and outlines the approved methods for handling such incendiaries. Likewise he reviews the wide range of industrial applications that make use of the thermit reaction in welding for repair and new construction and in producing carbon-free metals and alloys. —*Editors.*



Cross section of small magnesium incendiary commonly used in this war

UNTIL LATELY the word "thermit" appeared only in the lexicon of the chemical and metallurgical engineers. But now that thermit has become an instrument of war, more and more people are familiar with it, although it is doubtful if any but the student of alumino-thermics has a real grasp of all of its present applications.

The high temperatures of the thermit reaction are used for welding, in repair and in new construction work. The thermit process is utilized to produce carbide-free metals and alloys. Thermit is used alone and as a priming charge in the manufacture of incendiaries of different types. And there are many other applications still to be explored.

The science of alumino-thermics is based on the long-known fact that aluminum has a great affinity for oxygen. Even half a century ago this principle was the basis of a method of reducing a number of metals from their respective oxides. But the difficulty that existed then was that metallurgists assumed that it was necessary to heat their thermit mixtures until the reaction took place, since even finely divided aluminum will not burn at a temperature much below that of molten cast iron. The results were initial temperatures so high at the moment of ignition as to produce explosive reactions.

This light magnesium incendiary weighs only about two pounds

The discovery that a cold mixture of metallic oxide and finely divided aluminum could be ignited at one spot and that the reaction of this spot would furnish enough heat to propagate the reaction throughout the entire mass furnished science with the means of safely controlling the process. This was in 1895 or 1896.

An initial temperature of about 1150 deg. C. or 2100 deg. F. is needed to start the reaction. Once this temperature is provided, the aluminum, granular in form, burns in the oxygen supplied by the metallic oxide until it is consumed, leaving a molten slag of aluminum oxide over a bath of superheated molten metal. The temperature resulting from the reaction is computed to be over 5000 deg. F.

To start the reaction, an ignition powder, composed largely of some oxidizing agent such as barium peroxide, is employed. This may be ignited with a match, by a fuse, or, if in a bomb, by the flash of a fulminate cap or black or smokeless powder. The reaction is non-explosive and relatively slow, requiring about 30 seconds, and it proceeds throughout

Thermit reaction in welding heavy crankshaft

the entire mass up to a ton or more of material.

Incendiaries.—It was a German, Goldschmidt, who, while he was attempting to reduce chromium and manganese, discovered how to ignite thermit safely. His countrymen later applied this knowledge of alumino-thermics to the design of a magnesium-thermit incendiary bomb during the closing months of the first World War. Ludendorff, in his memoirs, reports that a number of incendiaries of this type were ready for use in 1918, but that the German High Command, knowing the conflict was nearing its end, did not order their use, fearing that thereby more severe peace terms might be imposed upon the German nation.

The modern magnesium-thermit incendiary used by Axis bombers on British and European cities has been described many times. The most common size weighs one kilogram or 2.2 pounds. It consists of a tube of magnesium alloy filled with a firmly packed thermit mixture, and fitted with tail fins and a firing mechanism. Since it was manufactured by the Griesheim-Elektron company, it sometimes is known as the Elektron bomb.

The bomb ignites on impact, a pin being driven into a firing cap that sets fire to a starting charge which in turn ignites the thermit. The temperature of the thermit reaction is more than sufficient to ignite the magnesium alloy tube which constitutes the body of the bomb. The high temperature generated by the thermit reaction within the tube builds up considerable pressure so that bits of molten metal, flame, and smoke are forced out of the vent holes. But this reaction continues only for about three minutes, and thereafter the magnesium burns with less vigor at a temperature of about 2300 deg. F. for fifteen minutes or more if undisturbed. A certain number of the bombs, called "discouragers," contain a light explosive charge that will go off during the thermit reaction.

Burning magnesium's ability to extract oxygen even from water is turned to advantage in disposing of bombs of this type. A spray of water directed on the bomb speeds up the rate of combustion so that the bomb will be consumed in about two minutes. If a solid stream of water is applied to the bomb, however, it will cause such an ebullient action as to spread the fire.

Thermit is used also in the petroleum type of incendiary to provide ignition. Inexpensive grades of oil with high flash points can thus be used. To prevent the petroleum from being scattered on impact, it is mixed with soap to form a wax-like solid. Metallic sodium or potassium may be mixed with the petroleum when attacks are made on waterfront objectives, because the vigorous reaction of these solids with water will ignite the oil. Petroleum bombs are generally of large size. Some of those dropped on London produced pillars of fire rising 30 feet in the air and 12 feet in diameter.

Thermit alone, in a steel bomb case fitted with tail fins and a firing mechanism, is reported to be a type of incendiary used by Japan. These are said to weigh 15 and 50 kilograms, and would have considerable penetration power. This type of bomb also ignites on impact and may contain an explosive charge. The thermit reaction, which transforms the metallic oxide and all the steel parts of the bomb into molten metal, is completed in about 30 seconds, and it is the great heat of this metal that carries the threat of fire.

The Chemical Warfare Service recommends, if there is a chance to minimize the incendiary effect of the molten metal, that a spray of water be directed onto it to cool it as quickly as possible below the ignition temperature of the combustible material with which it comes into contact.

There is a demonstration of the thermit reaction often made of late in training classes for civilian defense workers. A small quantity of a thermit mixture is placed in a paper cup and suspended above a container of water. A few inches below the level of the water a metal plate is suspended and at the bottom of the container is a layer of sand. The thermit is ignited with a starting mixture, and of course, it falls into the water and burns through the metal plate, dropping to the sand at the bottom of the container, where it glows briefly and causes the water to boil and bubble. This demonstration shows that thermit "even burns under water." The thermit reaction is practically completed when the residue of molten iron and slag burns through the metal plate, and what the spectator sees at the bottom of the container is the cooling metal.

The effect of thermit on ordinary carbonaceous material is not as positive as on steel. When burning on wood, for example, a layer of carbon forms under the molten iron, which serves to insulate the area below the hot iron against further burning. Thus, if a crucible is made on a 2-inch plank, and filled with thermit, the chances are that the thermit will not burn through the plank. But under the same circumstances, it would burn cleanly through a 1-inch steel plate.

For Welding.—Thermit, as employed for welding, is a mechanical mixture of finely divided aluminum and iron oxide in the form of magnetic iron scale. The proportions are, roughly, three pounds of iron scale to one of aluminum. This mixture reacts according to the equation:

$$8\ Al + 3\ Fe_3O_4 = 9\ Fe + 4\ Al_2O_3$$

Thus, expressed in weights, approximately three parts of iron oxide plus one part of aluminum will produce, when reacted, two parts of steel, and the steel produced by the reaction represents about one-half of the original quantity of thermit by weight and one-third by volume. The temperature resulting from the reaction is, as has been stated, over 5000 deg. F., but because of the chilling action of the crucible, the temperature of the liquid steel as poured into the mold for welding is slightly lower although still about twice as hot as ordinary molten steel.

Actual thermit mixtures used for welding contain materials other than aluminum and iron oxide. In designing such mixtures, many variables controlling both the time and the temperature of the reaction, as well as the required chemical analyses of the resultant weld metals, are taken into account. The time and temperature of the reaction can be varied somewhat by varying the size of the particles of the metallic oxide. Through the addition of metallic elements, either by means of metallic pieces which are melted during the reaction, or in the form of combinations of oxides of elements and aluminum, a wide variation in the analyses of thermit-made steels is provided. Table I gives the chemical formulae of the aluminum reductions of a number of oxides:

By the same means, tensile strength, ductility and hardness of the resultant steel are also controlled, and the range of physical properties made possible includes tensile strengths from 50,000 lb. per sq. in. up to 110,000 lb. per sq. in., with corresponding ductilities ranging up to more than 25 percent in the two inches.

The average analysis of thermit steel employed for welding is as follows in percentages:

Carbon	0.20 to .30
Manganese	.50 to .60
Silicon	.25 to .50
Sulphur	.03 to .04
Phosphorus	.03 to .04
Aluminum	.07 to .18

A thermit weld of this composition has an average tensile strength of about 65,000-70,000 lb. per sq. in. with an elastic limit of about 34,000-38,000 lb.; in fact, although cast, thermit weld metal may be regarded as actually having physical properties closely approaching those of forged steel.

The most commonly used thermits for welding ferrous metals are: *Plain thermit*—a mixture of finely divided aluminum and iron oxide, which is the basis for all thermit mixtures. *Forging thermit* — which is plain thermit with additions of manganese steel and mild steel punchings, and is used in welding parts made of forged steel. *Cast-iron thermit*—consisting of plain thermit with additions of ferro-silicon and mild steel punchings, used for welding cast iron. *Wabbler Thermit*—designed to produce a hard, machinable steel for building up worn wabbler ends of rolls and pinions in steel mills and similar applications.

WELDING METHODS

There are two methods of thermit welding. In the first, or pressure method, only the heat of the slag and the heat of the metal resulting from the reaction are utilized. In the second, or fusion welding, which is more widely employed, the thermit steel is deposited as weld metal.

In making a weld by the latter method, the first step is the lining up of the parts and the cutting of a parallel-sided gap at the point where the weld is to be made, the width of the gap depending upon the size of the section. Around the gap a wax pattern is formed and a refractory sand mold is built, which provides an annular space at the weld. The parts to be welded are then preheated to burn out the wax of the pattern and to dry out the mold. The thermit is placed in a specially designed crucible, and, when the reaction is complete, the crucible is tapped, allowing the thermit steel to run down into the mold. This steel, having 100 percent superheat, and being held in place by the mold between and around the ends of the part to be welded, gives up its superheat to these parts and fuses with them so that, upon cooling, a perfect fusion weld is provided.

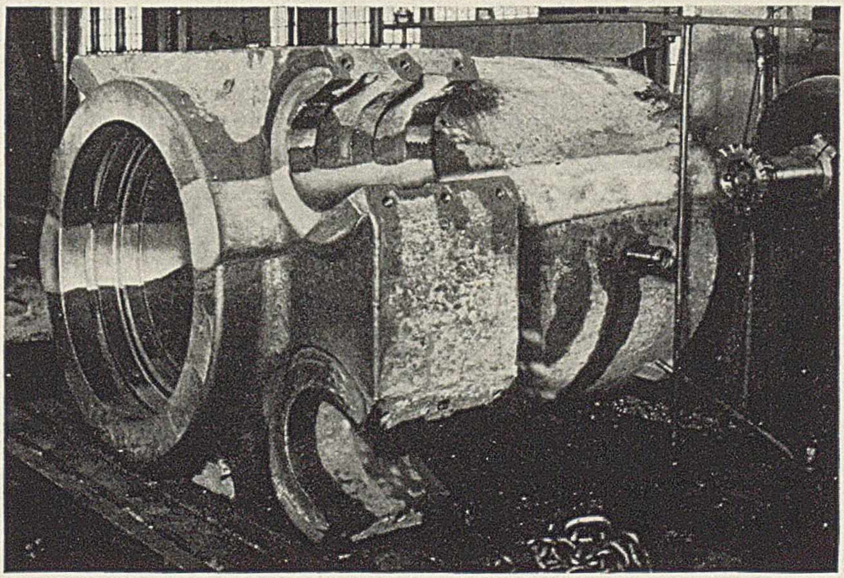
Most thermit welds in crankshafts, stern frames of ships, and machine parts are made in this way. In rail welding, however, which involves the making of a large number of identical welds, molds are made on standard patterns conforming to the sections of the rail being welded, and the making of wax patterns is dispensed with.

Theoretically, there is no limit to the size of the section which may be welded by the thermit process. This is because the weld metal is deposited in bulk and all at one time. Cooling is at a uniform rate so there is only

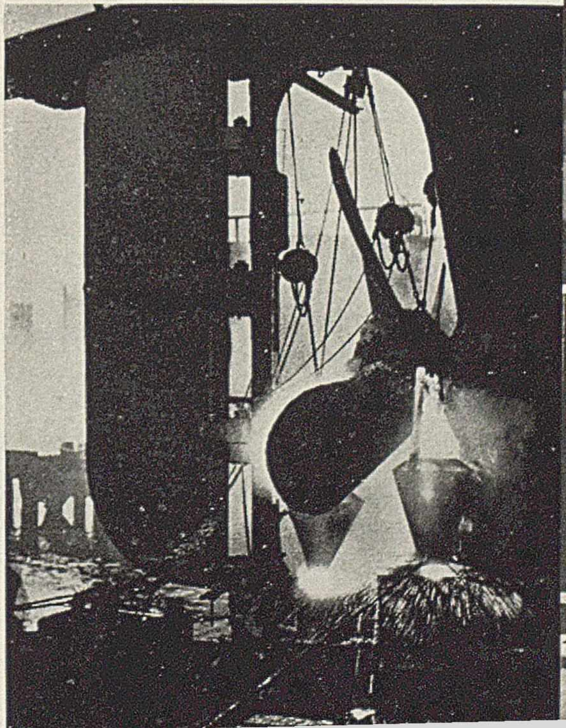
Table I.—Typical Thermit Reduction of Metallic Oxides

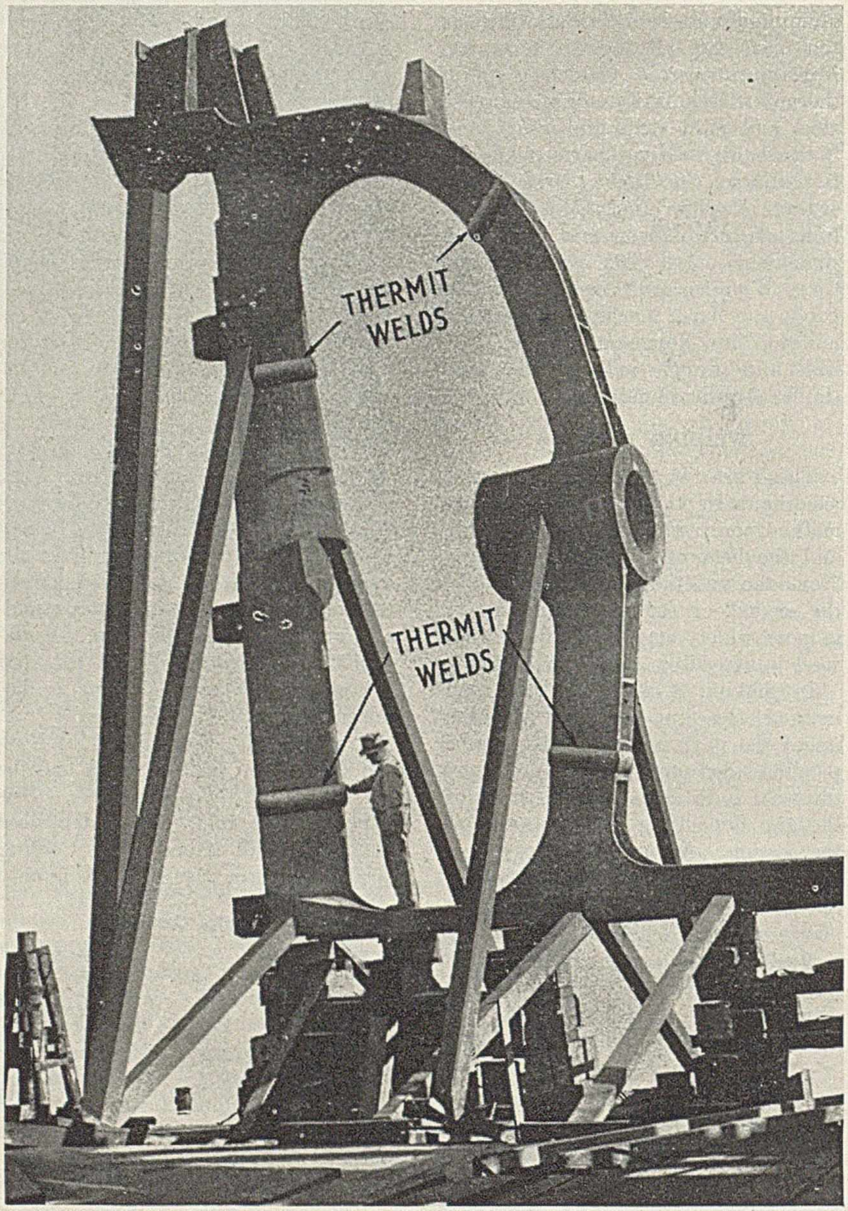
Metallic Oxides		*Aluminum*		*Resultant Slag*		*Resultant Metal*
$3Fe_3O_4$	+	8Al	=	$4Al_2O_3$	+	9Fe
Fe_2O_3	+	2Al	=	Al_2O_3	+	2Fe
$3Mn_3O_4$	+	8Al	=	$4Al_2O_3$	+	9Mn
Cr_2O_3	+	2Al	=	Al_2O_3	+	2Cr
WO_3	+	2Al	=	Al_2O_3	+	W
$3V_2O_5$	+	10Al	=	$5Al_2O_3$	+	6V
$3TiO_2$	+	4Al	=	$2Al_2O_3$	+	3Ti
3NiO	+	2Al	=	Al_2O_3	+	3Ni
MoO_3	+	2Al	=	Al_2O_3	+	Mo
$3SiO_2$	+	4Al	=	$2Al_2O_3$	+	3Si
B_2O_3	+	2Al	=	Al_2O_3	+	2B
$3Co_3O_4$	+	8Al	=	$4Al_2O_3$	+	9Co

This 25-ton hydraulic cylinder used in a rubber factory was repaired by thermit welding after serious rupture



Shipyards have long used thermit welding in repair and original fabrication





Welding together several small castings speeds construction of intricate equipment

one shrinkage in the entire weld. Local stresses are not present in correctly made welds.

The thermit reaction is used to produce carbide-free metals and alloys utilized by non-ferrous foundries and by makers of alloy steels. Such materials, produced by aluminum reduction, rather than carbon reduction, are quite pure and the absence of carbides is a distinct advantage in many applications. Shortages of aluminum, however, have somewhat restricted the use of this process.

In these ways, thermit serves the ends of both war and peace. Specialists working in the field of alumino-thermics agree that its use for many new applications awaits upon only the opportunities to explore and perfect them.

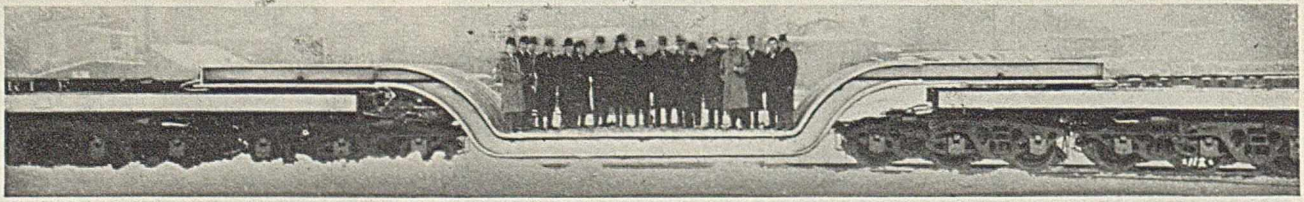
Education Looks to The Future

In his address at the dedication of the new building of Northwestern Technological Institute in Evanston, Ill. on June 16, President Karl T. Compton of the Massachusetts Institute of Technology predicted that engineering education will continue to grow into new fields of application with different techniques and methods of approach. He suggested that the trend in chemical engineering education might well prove a pattern to be studied by other branches of the profession. His remarks in that connection are given in the following paragraphs.—Editor.

FUTURE IMPROVEMENTS in engineering education may well be expected to follow along a path which was laid out by the chemical engineers. In the earlier days of this subject, training in chemical engineering consisted in the study of a great variety of standard processes of chemical manufacture, procedures like the Solvay process, or the LeBlanc process, or the Bessemer process.

Just about a generation ago a very important improvement was made in chemical engineering education. Attention was focussed on the various typical operations which were common to many types of chemical manufacture,—operations such as evaporation, distillation, transfer of heat, mixing, grinding, flow of liquids through pipes, etc. By studying thoroughly the basic theory of such operations and the techniques for handling them, the student became equipped with a method for tackling the various units which together form a manufacturing process, with a thorough knowledge of how and why they operate, but without having his mind cluttered up with the details of this or that particular chemical or material. This new concept of engineering education in the field of chemical manufacture was instantaneously successful and has resulted in chemical engineering's becoming one of the most useful and active of all engineering professional fields.

Thermit welding was used in fabricating frame of world's largest freight car



Maintenance Tips For Engineers

HOW TO KEEP MOTORS RUNNING AND AVOID LOST OUTPUT THROUGH MAINTENANCE

O. F. VEA *Motor Division, General Electric Co., Schenectady, N. Y.*

PRESENT-DAY conditions make it necessary that all electric motors be babied. Maintenance programs must be intensified to prevent breakdowns, because 24-hour-a-day, 7-day-a-week war production schedules cannot be interrupted—output lost today cannot be made up tomorrow. Even the failure of an inconspicuous piece of equipment can cause a considerable disruption in production.

A real maintenance program begins with selection. Motors must be chosen that are properly rated and protected for their work. The selection involves a study of requirements, such as continuous or intermittent duty, starting, torque, speed regulation, and the like. These all have a bearing on just what type of motor to choose.

In addition, the environment in which the motor is to operate should be considered, as this determines whether an open motor or some form of inclosed motor should be used, and how the motor should be located with respect to the driven load.

The next point to be considered is installation. The motor should be located in such a way that it is accessible for inspection and repairs. Of course, it is always advisable to install the motor in a place free from adverse conditions unless it is built in a protecting inclosure. It is also important to see that the motor has ample ventilation so that heat losses will be carried away.

A standard motor should not be installed where the ambient temperature or normal temperature rise is more than 40 deg. C. The motor should be installed on a solid foundation which is free from vibration. If it is direct-connected or belted, care should be taken to secure proper alignment, which should permit rotor end-play within reasonable limits.

All these factors must be taken into consideration if inspection and maintenance are not to be discouragingly difficult.

Frequency of inspection and degree of thoroughness vary, and will have to be determined by the maintenance engineer. They will be governed by (1) the importance of the motors in the production scheme (that is, if the motor fails, will the whole works be shut down?), (2) percentage of time the motor operates, (3) nature of service, (4) environment. An inspection schedule must, therefore, be elastic and adapted to the needs of each plant. The schedule tabulated here, covering both a-c and d-c motors, is based on average conditions in so far as duty and dirt are concerned.

Every Week

1. Examine commutator and brushes.
2. Check oil level in bearings.
3. See that oil rings turn with shaft.
4. See that shaft is free of oil and grease from bearings.
5. Examine starter, switch, fuses, and other controls.
6. Start motor and see that it is brought up to speed in normal time.

Every Six Months

1. Clean motor thoroughly, blowing out dirt from windings and wipe commutator and brushes.
2. Inspect commutator clamping ring.
3. Check brushes and renew any that are more than half worn.
4. Examine brush holders and clean them if dirty. Make sure that brushes ride free in the holders.
5. Check brush pressure.
6. Check brush position.
7. Drain, wash out, and renew oil in sleeve bearings.
8. Check grease in ball or roller bearings.
9. Check operating speed or speeds.
10. See that end play of shaft is normal.
11. Inspect and tighten connections on motor and control.
12. Check current input and compare with normal.
13. Run motor and examine drive critically for smooth running, absence of vibration, worn gears, chains, or belts.
14. Check motor foot bolts, end-shield bolts, pulley, coupling, gear and journal setscrews, and keys.
15. See that all motor covers, belt and gear guards are in good order, in place, and securely fastened.

Once a Year

1. Clean out and renew grease in ball or roller bearing housings.
2. Test insulation by megger.
3. Check air gap.
4. Clean out magnetic dirt that may be hanging on poles.
5. Check clearance between shaft and journal boxes of sleeve-bearing motors, to prevent operation with worn bearings.
6. Clean out undercut slots in commutator.
7. Examine connections of commutator and armature coils.
8. Inspect armature bands.

The competent maintenance man will have a record card for every motor in the plant. All repair work, with its cost, and every inspection can be entered on the record. In this way, excessive amounts of attention or expense will show up and the causes can be determined and corrected.

Inspection records will also serve as a guide to tell when motors should be replaced because of the high cost to keep them in operating condition.

CHEM & MET PLANT NOTEBOOK

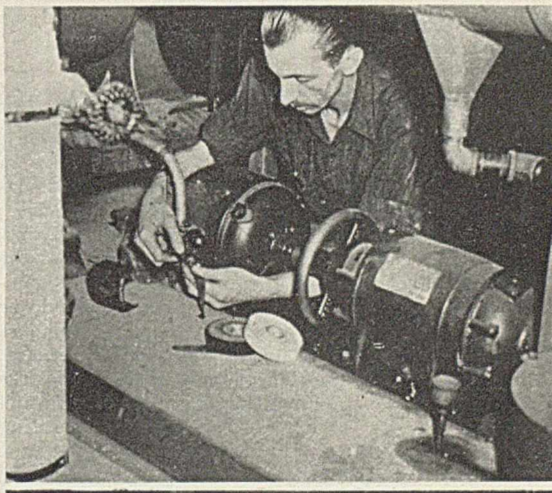
LUBRICATION

One of the major features of a maintenance program, from the standpoint of effect upon the general performance of a motor, is proper lubrication. Bearings of modern motors, whether sleeve, ball or roller, require only very infrequent attention. However, oiling and greasing of new motors is quite often entrusted to careless attendants who have been used to lubricating older designs, with housings less tight than on modern machines.

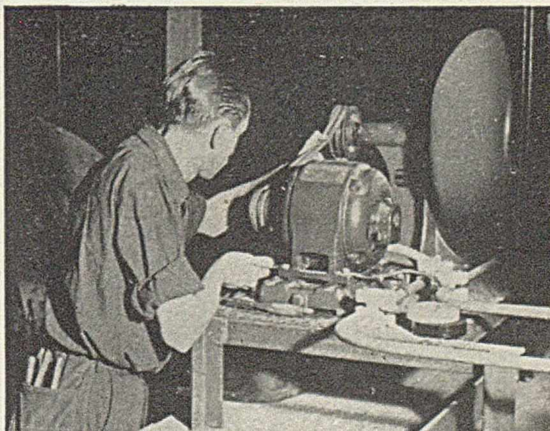
If the proper amount of a suitable lubricant is applied before starting, there should be no need to refill the housings for several months, even in dusty places.

Only a high grade of grease, having the following general characteristics, should be used for ball-bearing lubrication:

1. Consistency a little stiffer than that of vaseline, maintained over the operating-temperature range.
2. Melting point preferably over 150 deg. C.



Connections to a motor should be made tightly enough so that vibration of equipment will not loosen them. Wires joined in a conduit box should be either twisted together and soldered, or bolted together. Joints should be wrapped with rubber tape and then with friction tape



Install motors in such a way that they are accessible for inspection and repairs. Care should be taken to align the motor properly with driven load

3. Freedom from separation of oil and soap under operating and storage conditions.
4. Freedom from abrasive matter, acid, and alkali.

Specific instructions for the individual design should be followed if possible, rather than general rules.

In motors equipped for the pressure-relief method of greasing, greasing tends to purge the bearing housing of used grease. Complete cleaning of bearings, therefore, is required at infrequent intervals only. Carbon tetrachloride or other grease solvent is suitable for a thorough and convenient flushing when the bearings are not disassembled.

INSULATION CARE

Care of insulation goes hand in hand with lubrication as one of the major features of a motor maintenance program. These features concern the most vital, and probably the most vulnerable, parts of a motor.

Motors that have been long in transit in a moist atmosphere, or idle for an extended period, should be thoroughly dried out before being placed in service. Since machines sometimes "sweat" as a result of a difference in their temperature and that of the surrounding air, they should be kept warm at all times to prevent this condition.

Current at a low voltage can be passed through the windings, electric heaters can be used, or even steam pipes can be utilized for protective purposes. In the case of extended idle periods, tarpaulins may be stretched over the motor and a small heater put inside to maintain proper temperature.

The most effective method of drying out motors that have become wet by accident or because of "sweating" is to pass current through the windings, using a voltage low enough to be safe for the winding in its moist condition. Thermometers should be placed on the windings to see that they are heated uniformly. Temperatures should not exceed 90 deg. C. (Class A insulation). This method is particularly effective on high-voltage motors, where the insulation is comparatively thick.

The time required for complete drying-out depends considerably on the size and voltage of the motor. Insulation resistance measurements should be taken at intervals of four or five hours until a fairly constant value is reached. These tests are a good indication of the general condition of the insulation and its ability to stand the operating voltage.

Insulation resistance tests should also be made before a high-potential test, to determine whether the insulation is ready for such a test, and afterwards to make certain that the high potential has not injured the insulation. High potential tests should be made after drying out or after repairs to check the dielectric strength of the insulation.

New windings should successfully stand a high-potential test of twice normal voltage plus 1,000. Motors that have been in operation for some time should be tested with this method, *after thorough cleaning and drying,* using a voltage of about 150 percent of normal voltage, applied for one minute.

CLEANING MOTORS

A systematic and periodic cleaning of motors is necessary to insure best operation. If conditions are severe, open motors may require a certain amount of cleaning each day. For less severe conditions, weekly inspection and partial cleaning are desirable.

For the weekly cleaning, the motor should be blown out with dry compressed air (about 25 to 30 lb. per sq. in. pressure). Where conducting and abrasive dusts are present, even lower pressure may be necessary, and suction is to be preferred, as damage can easily be caused by blowing the dust and metal chips into the insulation. On larger d-c machines, the air ducts should be blown out so that the ventilating air can pass through as intended.

In cleaning a motor, the heavy dirt and grease should first be removed with a heavy, stiff brush, wooden or fiber scrapers, and cloths. Grease, oil, and sticky dirt are easily removed by applying a cleaning liquid such as carbon tetrachloride, gasoline, or naphtha, preferably by spraying it on. While the insulation will dry quickly at ordinary room temperature after cleaning, it is highly desirable to heat it to drive off all moisture before applying varnish. If the motor can be spared from service long enough, the insulation should be dried out by heating to from 90 to 100 deg. C.

While the motor is warm, a high-grade insulating varnish should be applied. For severe acid, alkali, or moisture conditions where oil or dusts are present, special varnishes can be supplied. If the machine must be put back in service quickly, or if facilities are not available for baking the varnish, fairly good results will be obtained by applying one of the quick-drying black or clear varnishes.

GENERAL OVERHAULING

Motors should usually be given an overhauling at intervals of five years or so, normally, or, if the service is more severe, more frequently. Such a practice is beneficial in avoiding breakdowns and in extending the useful life of the equipment. Where periodic overhauling is practiced, the following notes may be helpful.

Check the motor air gap, between stator and rotor, with feelers for uniformity. Small clearance at the bottom may indicate worn bearings.

Take the motor apart and inspect it thoroughly. Measurement of the bearings and journals may indicate need for new bearing linings. Remove the waste from waste-packed bearings and rearrange or replace it, so that any glaze on the wool is removed from its point of contact with the shaft. Any gummy deposit means that the wool should be replaced. All lubricant should be cleaned out of the bearings and a fresh supply put in when the motor is reassembled.

The rotors should be cleaned with a solvent to remove any accumulated dirt, after which any rust should be removed with fine sandpaper (not emery paper). When clean and dry, the rotors should be coated with a good grade of clear varnish or lacquer to protect them from moisture. To prevent injury to the bearings, they should be completely protected with a clean rag when the motor is disassembled.

The rotors of wound-rotor motors should be given the same treatment as the stators. In addition, soldered joints and binding cords should be inspected and any weakness remedied.

The stator bore should be cleaned of dirt with a solvent, and any rust should be removed with fine sandpaper (not emery paper).

D-C MOTORS

To insure efficient operation of d-c motors, inspection and servicing should be done systematically. The first essential for satisfactory operation of brushes is free movement of the brushes in their holders. Uniform brush pressure is necessary to assure equal current distribution. Make sure that each brush surface in contact with the commutator has the polished finish that indicates good contact, and that the polish covers all of this surface of the brush. Check the freedom of motion of each brush in the brush holder.

When replacing a brush, be sure to put it in the same brush holder and in its original position. When installing new brushes, fit them carefully to the commutator. To do this, insert a strip of fine sandpaper, sand side up, between the commutator and the brush. Rotate the commutator back and forth, allowing the brushes to bear on the sandpaper only when the commutator is moving in the proper direction of rotation. Then check the springs that hold the brushes against the commutator. Improper spring pressure may lead to commutator wear and excessive sparking.

Inspect the commutator for color and conditon. It should be clean, smooth, and a polished-brown color where the brushes ride on it. A bluish color indicates overheating of the commutator. Roughness of the commutator should be removed by sandpapering or stoning. Never use emery cloth or an emery stone. For this operation, run the motor without load. If the armature is very rough it should be taken out and the commutator turned down in a lathe. When this is done, it is usually necessary to cut back the insulation between the commutator bars slightly. After turning down the commutator, the brushes should be sanded and run in as described previously.

CHEM & MET REPORT ON

War-Time Construction in Chemical Process Industries

War has added many burdens on backs of the industries that are building war plants. Unfortunately, these burdens must be carried by Industry for it is Industry not W.P.B. or any other governmental agency that has this job to do. And, more specifically, it is the responsibility of the individual industry that undertakes war work to get its job done in spite of hell, high water and red tape. So this report has been prepared to help clear the way for action by suggesting procedures and short-cuts, and by answering some of the questions being asked us most often by chemical engineers, manufacturers and equipment fabricators. We have been told, for example, that there is going to be a lull in the construction program. But does that mean that essential plant construction should stop? Does W.P.B. or any other agency really believe that no more productive capacity is needed now? We think *not*. What it really means is that some things like synthetic rubber, 100-octane gasoline and chemical warfare materials, for example, may be needed more than some other things so that, if necessary, more capacity of otherwise essential war materials may have to be delayed. This is a challenge as well as a real opportunity for the chemical engineer. The pages that follow should help him meet that challenge.

CHEMICAL AND METALLURGICAL ENGINEERING • JULY, 1942

War-Time Construction in Chemical Process Industries

SUMMARY AND CONCLUSIONS

Three recent governmental regulations vitally affect new plant construction in the chemical process industries. First in importance, perhaps, is the "Directive for War-Time Construction" dated May 20, which sets up seven basic criteria that must be met before any project can be approved. Second, is the List of Prohibited Items which says, in effect, that no building can be done unless the raw materials to be consumed are less critical than the final product. Third is Conservation Order L-41 prohibiting the start of all *unauthorized* construction projects that exceed certain maximum costs,—$5,000 per year in the case of industrial buildings.

Despite these burdensome regulations, there are still many new plant projects in the chemical engineering field that must be pushed ahead intelligently and effectively during the next few months. Except for the synthetic rubber, aviation fuel and the new explosives and chemical warfare plants, these projects are generally smaller in size than the major chemical expansion programs that have already been completed or are still under way. But they are extremely important in order to remove bottlenecks in existing plants and to provide essential catalysts, inhibitors, plasticizers and similar ingredients.

To help in expediting this work, the Chemicals Branch of the War Production Board has set up a Project Rating Unit in the Railroad Retirement Building in Washington under the direction of Ben H. Wilcoxon, a chemical engineer of excellent training and experience. In New York, on the 54th floor of the Empire State Building, Vernon Bishop represents the Chemical Branch in the Bureau of Construction of W.P.B. Both of these men are willing and able to assist those who have pressing problems in connection with war-time construction in the chemical process industries.

The information on which the following report is based has been obtained from both public and private sources. However, all interpretations and conclusions drawn from governmental orders are those of the editors of *Chem. & Met.* who assume entire responsibility. Careful study of these new regulations and the practical suggestions offered here in connection with them should promote more intelligent progress in meeting the continuing needs of the war program.

In the early days of the national defense program, the various governmental agencies were inclined to encourage all possible plant construction which would aid directly or indirectly in the war effort. It soon became apparent, however, that this vast expansion program would have to be curtailed because of two reasons: (1) Shortages of raw materials and equipment were becoming so acute that it was almost impossible to build even A-1-a projects on schedule and (2) all possible materials and equipment should be diverted into direct military requirements.

Chemical engineers and others concerned with the problem of getting war plants built and into operation in time to be of most effective service began to run into increasing difficulties. At first it was merely a matter of getting the necessary men, money and materials. Then came priorities and the complicated maneuvering for project ratings in the case of the most essential undertakings. Gradually the controls began tightening and on April 1, 1942, the Army and Navy Munitions Board published its "List of Prohibited Items for Construction Works." And all this reached a sort of a climax April 9 with the issuance of Conservation Order L-41 which virtually put a stop to all major construction undertaken without prior governmental approval. Subsequent rulings and interpretations of L-41 made it clear that practically all industrial projects costing more than $5,000 during any continuous 12-month period could not proceed without specific governmental authorization.

Within a matter of weeks, it became apparent that L-41 was only preliminary to the real climax. This came on May 30 in the exceedingly important "Directive for War-Time Construction." Duly recommended by William H. Harrison, Director of Production for W.P.B., it carried the approving signatures of Donald M. Nelson, Chairman of W.P.B., Henry L. Stimson, Secretary of War and Frank Knox, Secretary of the Navy. Because of its basic importance as a statement of guiding principles to govern all war-time construction, this directive is reprinted herewith in its entirety.

DIRECTIVE FOR WAR-TIME CONSTRUCTION

To make available all possible material and effort for immediate war production, the following paragraphs outline the principles governing war-time construction:

1. In order that the consumption of materials and equipment by construction activities shall not impede the production of combat supplies and equipment, it is essential that all construction whether financed by the Government or other funds, be reduced to the absolute

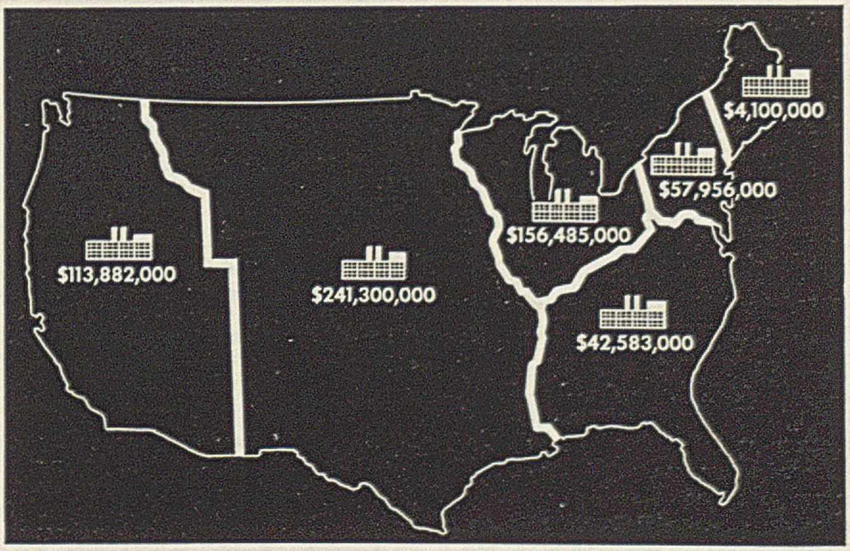
minimum necessary for the war effort. This applies also to construction essential for vital civilian needs.

2. Reduction in the consumption of materials and equipment by construction operations can be achieved either by the elimination of non-essential projects or parts thereof, by deferring projects not needed immediately, or by appropriate changes in design and construction methods which will favor the use of those materials which are most plentiful and which will interfere least with the production of combat material.
3. In order to establish effective measures for the control of construction, the following general policies have been established by the War Production Board, in consultation with the War and Navy Departments.
4. Before any construction project can proceed, it must be acted upon affirmatively by some agency of the Federal Government or by its duly authorized representative. No project will be approved for construction unless it is found, by responsible authority, to meet the following criteria:
   - (a) It is essential for the war effort.
   - (b) Postponement of construction would be detrimental to the war effort.
   - (c) It is not practicable to rent or convert existing facilities for the purpose.
   - (d) The construction will not result in duplication or unnecessary expansion of existing plants or facilities now under construction or about to be constructed.
   - (e) All possible economies have been made in the project, resulting in deletion of all non-essential items and parts.
   - (f) The structure of the project has been designed of the simplest type, just sufficient to meet the minimum requirements. See Paragraphs 5 and 6 also.
   - (g) The answers to the following questions relating to conditions at the proposed site are all affirmative to the extent that they are pertinent:
     - (1) Are there sufficient labor and materials available to build it?
     - (2) Will adequate public utilities be available without costly extensions?
     - (3) Will transportation be available to serve it?
     - (4) Will labor be available to man it? (Are housing and other community facilities adequate?)
     - (5) Will machine tools and other equipment be available to equip it?
     - (6) Will raw materials be available to operate it?
     - (7) Can the manufactured product be used at once —or stored until needed?
5. *Priority of materials*—In general, all construction shall be of the cheapest, temporary character with structural stability only sufficient to meet the needs of the service which the structure is intended to fulfill during the period of its contemplated war use. Ordinarily, wood-frame construction is preferable to reinforced concrete, and reinforced concrete is preferred to steel. However, the guiding principle should always be to *utilize those materials which are most plentiful* and which, in the ultimate analysis, will cause the least interference with the production of combat material and the utilization of transportation and power.
6. Mechanical and electrical features should be reduced to bare essentials. Air conditioning may only be used where manufacturing processes make its use essential and not for the comfort or to increase efficiency of personnel. Electrical systems shall be of the simplest designs.
7. Construction materials and the end products, the use of which is prohibited by the Army and Navy Munitions Board directive, "List of Prohibited Items for Construction Works," dated April 1, 1942, and revisions thereof, shall not be specified, purchased, or used except under special waiver issued by competent authority as provided for.
8. *Enforcement* — Each department having cognizance of construction work will require its subordinate activities to comply strictly with the foregoing general policies and any extensions thereof issued by proper authority. Each department shall arrange for frequent and adequate spot checks of its projects to make sure that all subordinate agencies of the department concerned are rigorously conforming to the established policies. Furthermore, violations of these policies must be followed by proper diciplinary action and the imposition of suitable penalties.
9. It should be made clear to all concerned that these general policies should govern not only direct construction for the War and Navy Departments but also other construction financed directly or indirectly with Government funds, and all private construction. The evasion of the requirements of the general policies by manufacturers or other parties will result in the imposition of penalties.
10. The War Production Board, the Army and the Navy shall take immediate steps to effectuate in detail this directive. It is particularly important that any governmental agency which has contact with or control of privately-owned expansions see to it that no violations of this directive occurs.

LIST OF PROHIBITED ITEMS

In order to reduce the consumption of material and equipment on approved construction projects to the absolutely essential minimum, the Directive for War-Time Construction incorporated the A.N.M.B. "List of Prohibited Items for Construction Work," dated April 1, 1942, and revisions thereof as part of the directive governing all construction. This list of prohibited items specifically includes certain permitted uses and certain prohibited uses of aluminum, asbestos, brass, bronze, burlap, cadmium, chromium, copper, cork, corkboard, granulated cork, gas, hemp, jute, lead, magnesium, mahogany, manila, mercury, Monel, nickel, oakum, plywood, rubber, silk, sisal, spruce, steel and iron, tin, tung oil, vanadium, wool and zinc.

Earlier conservation lists dealt largely with construction materials for building. However, this new list gives consideration to air conditioning, refrigerating systems, oil refining plants, power plants, material re-



Contracts for new plant construction in the Chemical Process Industries, public and private, totalled $616,309,000 for the first 6 months of 1942 as compared with $140,504,000 for same months of last year

quirement for equipment, etc. This listing is not included in this article as it is now undergoing revision, and is expected to be re-issued within a few weeks.

Provided that a proposed project has met the requirements of the two Government regulations described above, then it becomes necessary to obtain Government authorization for construction.

CONSERVATION ORDER L-41

In order to put into effect the policy set forth in the directive for war-time construction, Conservation Order L-41, dated April 9, 1942, prohibits the start of unauthorized construction projects.

The order specifically provides that no residential construction except for maintenance and repair work may be started without permission if its estimated cost is $500 or more. Similarly, no new agricultural construction may be started if the estimated cost is $1,000 or more for the particular building or project involved. No other construction, including commercial, industrial, recreational, institutional, highway, roadway, sub-surface and utilities construction, whether publicly or privately financed, may be initiated without permission if the cost of the project amounts to $5,000 or more.

In computing such costs, the amount spent on the project within 12 months of the date of beginning construction, and subsequent to April 7, 1942, is included.

Specific types of construction, however, are necessarily exempt from the provisions of the order. These include:

1. Projects which will be the property of the Army, Navy, Coast Guard Maritime Commission and certain other listed agencies of the Federal Government;
2. Projects to reconstruct or restore residential property damaged or destroyed on or after January 1, 1942, by fire, flood, tornado, earthquake or the public enemy.
3. Projects of the type restricted or controlled by provisions of the orders of the M-68 series, which cover the production and distribution of petroleum.

Where priority assistance is granted by the War Production Board, authority to commence construction will be issued by the Director of Industry Operations on appropriate forms of orders in the *P* series.

These include preference rating orders of the P-14 series, P-19 series, P-41, P-46, P-55, P-98, P-110 and P-115. (See following Appendix *A* for types of construction). Preference ratings extended on PD-1 or PD-1A forms or by any other *P* order than those listed in the L-41 order do not constitute authorization to begin construction.

In all cases of chemical projects involving building construction where the cost of the project is over $5,000 per annum, it is necessary to file Form PD-200, even though only a small number of priority ratings are required. This, of course, does not apply to maintenance or repair. As defined in L-41, maintenance means upkeep of a building, structure or project in sound working condition. Repair means the restoration, without change of design (See par. "f" below), of a building, structure or project to sound working condition, when such portion has been rendered unsafe or unfit for service by wear and tear, damage or other similar causes. In order to make the definition of repair less rigid Interpretation No. 1 of Conservation Order L-41 was issued June 6, 1942 (W.P.B. Release 1305), which reads:

(a) The term "Construction" in paragraph (a) (2) does not include the excavation or other movement of earth where no material except earth or other unprocessed material is to be incorporated.

(b) In connection with paragraphs (a) (3), (a) (4), and (a) (5), where part of a building, structure, or project falls within one class under said Order and other parts within another or other classes, the predominant designed use shall determine classification of the whole construction.

(c) In connection with paragraphs (a) (4) and (a) (5), a structure to be used primarily for the storage of farm products

Appendix A—Conservation Order L-41

The following Preference Rating Orders and Certificates are listed pursuant to paragraph (b)(7)(i) of the above Order. A general description of the type of construction covered by each, the appropriate application form and where such form should be filed are given solely for purpose of identification.

Preference Rating Order	Type of Construction	Application Forms	Where Filed
P-14-a P-14-b	Shipyards and shipways	No form	Maritime Commission Washington, D. C.
P-19 P-19-a	Buildings, structures and projects important to the war effort and essential civilian needs, other than housing	No further application accepted under P-19 and P-19-a. Apply for P-19-h or P-19-i	
P-19-d P-19-g	Publicly financed housing	Application is made only by the federal agency principally interested in the construction	————
P-19-e	Public roads	Application is made by or through the Public Roads Administrative of PWA	————
P-19-h P-19-i	Buildings, structures and projects important to the war effort and essential civilian needs other than housing	Forms PD-200 and PD-200A	With the field office of FHA having jurisdiction of the site
P-41	Construction of air transport facilities	See Order	————
P-46	Certain types of utilities construction	See Order	————
P-55 P-55 amended	Privately financed Defense housing	Form PD-105	With the field office of FHA having jurisdiction over location of the site
P-98	Construction related to Petroleum Enterprises as defined and limited therein	See Orders in M-68 series	————
P-110	Remodeling of housing in defense areas	Form PD-406	With the field office of FHA having jurisdiction over the location of the site
P-115	Expansion of Canning Plants	Form PD-285	With WPB, Washington
Certificates			
PD-3 PD-3A	Principally buildings structures and projects owned or to be owned by the Army, Navy or certain other governmental agencies	Form PD-3A	With the contracting or procurement official having jurisdiction over the contract

which are produced by a person other than the proprietor of such structure shall be interpreted to be "Other Restricted Construction."

(d) The Cost of Construction, as defined in paragraph (a) (7), shall include the Cost of an article, chattel or fixture if such article, chattel or fixture is to be (a) physically incorporated in and used as part of the construction; or (b) so substantially affixed to the construction that it may not be detached without materially injuring it or the construction.

(e) The Cost of Construction, as defined in paragraph (a) (7), shall include neither (a) the value of used material, including equipment, which has been severed from a building, structure or project and is to be used in the construction, without change in ownership; nor (b) the estimated cost of labor in incorporating such used material.

(f) The term "Without Change of Design" in paragraph (a) (9), is interpreted to permit change in material or type of equipment if the architectural or structural plan is not substantially altered in effecting such change.

(g) In determining whether the estimated cost of a particular building, structure or project exceeds the cost limits permitted under paragraphs (b) (4) (i), (b) (5) and (b) (6), over any continuous twelve-month period, the cost of any construction thereon during said period authorized under the provisions of paragraph (b) (7) shall not be included.

A literal interpretation of this order is that each integrated portion of a chemical plant is limited to $5,000 of new work other than repair and maintenance per year for each product. This would, of course, work a serious hardship on major companies in the chemical process industries which are continually making minor alterations and additions to plants, which will usually total far in excess of the $5,000 per year figure. Accordingly the administrators of L-41 are making attempts to remove this burden which would otherwise require filing numerous PD-200's for very minor projects.

Chem. & Met. is informed that until further notice is given, all projects should be filed in accordance with the following instructions:

(a) All chemical construction on which no priority assistance is required will be made on Form PD-200 in the usual fashion. The applicant should indicate that no priority assistance is required. If that is the case, these should be filed with the Construction Bureau, 54th floor, Empire State Building, New York City.

(b) All chemical construction on which priority assistance is required should be prepared on Form PD-200 in the usual fashion and sent to Washington.

PREPARING FORM PD-200

Form PD-200 was designed by W.P.B. to be a general form to cover all types of construction. Accordingly, if only the questions asked on the form are answered, it is difficult for the analysts in W.P.B., in the case of chemical plant construction, properly to evaluate the merits of the individual project and to ascertain that all possible conservation measures have been exercised in designing the plant. Further information is highly desirable. The purpose of the following suggestions is, therefore, to permit more rapid clearance of the project when filed, and to avoid the delay encountered in going back to the applicant for further information, and in redesign, which has been required in many instances. Much time can be saved by properly preparing the PD-200 and exercising conservation in design. In order to justify the project, the applicant should endeavor to answer the items covered by the following outline:

A. Present Situation

1. Present production.
2. Approximate breakdown of distribution of present production by end use where possible.

B. Objections to Present Situation

1. Why are new facilities required?
2. What would be the position of the company insofar as meeting defense requirements if project were not constructed?
3. Discuss alternate means of fulfilling defense demands.
4. What would be the effect on civilian consumption if proposed facilities were not constructed?

C. Proposal

Describe project in detail as follows:

1. Define clearly just what facilities are covered by the project.

For example:

This project includes the installation of two identical units for the production of ...., each unit consisting of equipment for the recovery of......from...... streams, the polymerization of this ......which is then finished as .... The required equipment consists of fractionating towers, drums, storage tanks and spheres, heat exchangers, pumps and drivers, compressors, instruments, finishing and packaging equipment, power and steam distribution facilities, sewers and drainage systems, fire protection system, roads, railroad spur, and fences. Approximately 12 buildings are involved of which five comprising approximately 7,500 sq.ft. of floor space will be of brick, steel, and concrete construction. The remaining seven buildings, comprising approximately 65,000 sq.ft. of floor space, will be of structural steel frame with corrugated asbestos roofing and siding.

2. Indicate the cost of materials as well as the total cost of the project.
3. What increase in production or improvements in operation will be effected by the proposal?
4. Include sufficient information in regard to building and structural work to indicate the type of design.
5. Include a brief sketch or flow sheet of proposed facilities so that the analysts can readily visualize the facilities which are to be constructed. Preferably, this flow sheet or sketch should show the relationship to existing facilities. In justifying the application it is particularly helpful to have a flow sheet showing the distribution and quantities required throughout the plant.
6. Where critical materials such as copper, copper alloys, aluminum, nickel and stainless steel alloys are required, the composition of alloys should be indicated and it should be stated whether solid, clad or lined construction is utilized.
7. Furnish a detailed tabulation of all buildings, process equipment, utilities, appurtenances, etc., covered by the application, breaking the items down into the necessary materials of construction *where practical*. For example: Condensers should be broken down into steel plate, tubing, etc., columns into steel plate, alloys, castings, etc. Refer to Appendix B for suggested form. Material cost should be based upon the fabricated cost of equipment delivered to plant site. Any other basis may be substituted as long as applicant so indicates and is consistent.
8. It is presumed that Item 7 will be a detailed list of all items covered by the project.
   Prepare a recapitulation of critical materials and equipment. Refer to Appendix C. The recapitulation should be particularly accurate with respect to steel plate, nickel, Monel, alloy steel, copper, copper alloys, aluminum, tin, and rubber.
9. Indicate clearly your raw material position. List all principal chemical raw materials as well as electric power required for processing after completion of the plant. It is suggested that raw materials be given in terms of pounds per pound of product. Also describe what arrangements, if any, have been made for obtaining these requirements of raw materials.

D. Justification

1. Justification of entire project. While the burden of justifying the entire project rests with the Defense Agencies, the applicant usually has readily available information which will help justify the Project.
2. Justification of process used—This is necessary only when several processes could be used, some of which are more attractive from a national point of view with respect

to the utilization of critical materials for construction and of critical chemicals as raw materials. A good example is phenol.

3. Justification of appurtenances—This applies particularly to utility systems, tankage, etc. For example, if power generating facilities are included, these should be described in detail, indicating applicant's position in event it is impossible to furnish the power generating facilities at the same time the plant is to be completed. In all cases adequate information should be furnished, showing your present power facilities and the necessity for increased capacity. In the case of tankage, instrumentation and other appurtenances, it should be established that these are designed to a minimum.
4. Justification of critical materials in construction of buildings and structural work. Refer to Appendix D for a tabulation of suggestions which will probably pass the Conservation Section of W.P.B. with a minimum of delay. If these design suggestions are being adhered to, it should be so stated in the application. If not, it is suggested that sufficient supporting information be submitted to justify any necessary deviation. In many cases blueprints or sketches of the structural work would be helpful.

Appendix B—Suggested Form for Tabulation of Buildings, Equipment and Appurtenances

Buildings	Unit of Measures	No. of Units	Value
1—20′ x 80′ x 15′ high reinforced concrete building..............			$20,000
Structural steel	tons	40	
Process Equipment			
Furnaces			
1—5,000,000 B.t.u./hr 10 x 20 x 14′ furnace..			$10,000
30-18-8 C.N. Tubes	tons	4	
30-18-8 C.N. headers	tons	1	
30-29-19 C.N. tube supports	tons	1	
Exchangers			
Bottoms cooler.........			5,000
½″ steel shell	tons	.45	
11-13% C.R. Tubes ¾″ x 14 Ga	tons	.20	
Columns			
6′ x 60″ acetone fractionating columns			10,000
¾″ steel shell	tons	6	
C.I. bubble trays	tons	1.4	
4-6″ C.R. Monel Steel Bolting	tons	.3	
Pumps			
1-6″ GPM feed pumps..			500
C.I. Case			
Steel impeller			
NI resist trim			
Reactor Vessels			
Separators			
Compressors			
Gas Holders			
Knock-out drums			
Accumulators			
Turbines			
Motors			
Instruments			
Process Piping			
Auxiliaries			
Loading Facilities	Detail as above		
R. R. Spurs			
Tankage			
Utilities			
Utility Piping			
Electric Power System			
Steam System			
Air System			
Sewer System			
Refrigeration System			
Salt Water System			
Fresh Water System			

5. Justfication of the use of critical materials such as copper, copper alloys, stainless steel, nickel, Monel, lead, rubber, cork, etc., in process equipment for corrosion resistance. Refer to following pages for a tabulation of design suggestions for process equipment. Wherein it is impractical to adhere to the suggestions it should be so stated and the deviations justified. Supporting data should be given to indicate the necessity of using Monel, nickel, aluminum, stainless steel. Sketches, flow diagrams, corrosion rates, temperatures, pressures, anticipated life, and all facts helpful in establishing the necessity of the materials requested should be included.

Appendix C—Recapitulation of Critical Materials and Equipment

Group I — Metals	
(1) Steel Plates	2,000 tons
(2) All other Carbon Steel	3,000 tons
(3) Cast Iron	3,357.4 tons
(4) Total Carbon Steel and Cast Iron	8,357.4 tons
(5) 18% Cr. 8% Ni.	187.9 tons
(6) 3½% Nickel	21.5 tons
(7) Admiralty 71% Cu. 28% Zn. 1% Sn.	34 tons
(8) Naval Bronze 88% Cu. 10% Sn. 2% Zn.	20.5 tons
(9) Copper	150.7 tons
(10) Brass 65% Cu. 35% Zn.	109.3 tons
(11) Hastelloy D 85% Ni. 3% Cu. 2% Fe. 10% Si.	17.5 tons
(12) Monel 70% Ni. 30% Cu.	3.5 tons
(13) Lead	381.6 tons
(14) Mercury	1 ton
(15) Rubber	2.2 tons
Group II — Building Materials	
Electrical Fittings or Appurtenances	112.5 tons
*Electrical Lighting Fixtures	1,425 units
Plumbing Fixtures	25 units
Portland Cement	15,000 bbl.
Brick — Common Red	292 M
Clay Pipe. Glazed Sewer Pipe	$5,000
Roof, pre-cast gypsum plank	11,160 sq.ft.
Construction Lumber	965 M.bd.ft.
Railroad ties — Treated	750 Pcs.
Insulation Board	82,500 bd.ft.
Corrugated Asbestos Cement Sheets	100,000 sq.ft.
Asbestos Sponge Felt	$54,000
Asbestos Sponge Felt	19,000 section
Heating Coils and Convectors (for buildings)	12 units
Group III — Process Equipment	
Pumps — 152 Units	$102,700
Cooling Towers — 2 Units	80,000
Boilers — 3 Units — 1,000 hp.	100,000
*Instruments	212,500
Finishing Equipment	370,000
Compressors — 12 Units — 1,500 hp.	561,600
Group IV — Drivers and Power Generation	
Turbines — 26 Units — 2120 hp.	$32,000
Motors — 238 Units — 4338 hp.	63,500
Transformers and Switchgear	93,000
Motor Starters — 238 Units	25,700
Group V — Appurtenances	
*Plant Telephone	$3,000
*Construction Tools and Equipment	70,000
*Laboratory and Office Equipment	2,500

* Metals for fabricating items marked with asterisk are not included in Items 1-15.

Appendix D—Conservation Suggestions in Regard to Buildings and Utilities

Critical Materials	Modifications, Suggested Alternatives and Options
Structural Steel	(1) Wood or (2) reinforced concrete except where structural steel is absolutely essential.
Reinforcing steel	Use wood in lieu of reinforced concrete wherever practical.
Steel Mesh	Omit in roadways and slabs on ground. Omit galvanized mesh.
Corrugated sheet iron, galvanized	Cement asbestos
Corrugated sheet iron, asphalt protected	Cement asbestos
Steel sash	Wood preferred, except for fire exposures.
Steel bucks, door, etc., frames	Wood preferred; painted steel clad, if necessary; for fire protection, use wood cored, metal-covered doors with terneplate covers.
Nails	Omit any galvanizing, except where absolutely essential.
Sheet piling	Wood creosote, if permanent.
Metal lath	Eliminate, if practical.
Fence	Restrict to enclose built-up areas. No galvanizing; use wood posts; no steel top rails.
Sheet Metal[1]	
Roofing, flashing	Built-up roofing, flashing ferrous, non-metallic coated, or tight zinc coated.
Down spouting and gutters	Ferrous, non-metallic coated, or tight zinc coated.
Weather stripping	Use galvanized non-metallic materials.
Screening	Ferrous painted.
Utilities	
Iron sewer pipe Steel sewer pipe Iron and steel sewer pipe fittings	Use terra cotta, standard or medium soil or concrete pipe wherever practical. Where iron is necessary, use minimum weight piping.
Steel gas lines	No galvanizing.
Water pipe lines (underground)	Over 3 in. diameter, use asbestos cement pipe, and/or over 24 in. use concrete pipe. Eliminate all galvanizing as far as practical.
Conduit	Use galvanized conduit only for extreme conditions; otherwise non-metallic coated. Eliminate conduit by use of non-metallic sheathed cable wherever practical. Use asbestos-concrete where possible.
Conduit fittings	Omit galvanizing wherever possible — use non-metallic coatings. Porcelain boxes where non-metallic sheathed cable is used.
Water storage tank	Use wood or concrete.
Electric lighting fixtures	For interior use, non-metallic type or light gage ferrous sheets, spun, stamped or drawn with non-metallic protective coating and non-metallic shades and reflectors. For exterior use, non-metallic shades or ferrous fixtures with non-metallic coating. Metal posts for supporting fixtures are not permitted. Copper or copper alloy permitted for current carrying parts. Socket shells and covers shall be non-metallic.
Heating	
Coils and convectors	No copper.
Radiators, iron	Iron.
Brass traps	Eliminate all possible brass; ferrous bodies for sizes over 2 in.
Miscellaneous	
Valves	Yellow brass valves permitted for 2 in. size and smaller: ferrous metal with yellow brass, stems, seats, and disks for larger sizes.
Steel rails	Attempt to use second-hand rails.
Office furniture and locker	Office furniture, lockers and shower stalls should be of non-metallic construction.
Stairs, railings, ladders	Use minimum amount of metal; use wood or concrete where possible.
Plumbing and heating fixtures	Use unplated ferrous fixtures.
Finish hardware	
Lavatory fixtures	Use vitreous fixtures.
Paint	No aluminum paint shall be used.
Switch and receptacle plates	Use non-metallic material.

[1] Galvanized iron and steel shall be used only where unusual conditions of corrosion exist. Copper shall be used only for electrical use and where corrosion permits substitution of no other less critical material. Use wood in place of metal wherever possible. Plated and ornamental iron and steel are not permitted.

SUGGESTIONS ON PROCESS EQUIPMENT

1. Observe conservation suggestions outlined in Appendix A where applicable to process equipment.
2. Make all possible substitutions down the list vertically. This list is a general guide and is subject to change.

Magnesium	Lead
Aluminum	Steel
Nickel	Silver
Monel	Glass-Lined
Stainless Steel	Glass
Tin	Reinforced concrete
Chromium Alloy	Tile
Copper	Brick
Copper Alloys	Wood
Zinc	

PD-200
1/2/42
ORIGINAL

WAR PRODUCTION BOARD
DIVISION OF INDUSTRY OPERATIONS

APPLICATION FOR PROJECT RATING

To: Director of Priorities, War Production Board, *Washington, D. C.*

INSTRUCTIONS FOR PREPARATION OF APPLICATION FOR PROJECT RATING

Fill out in quintuplicate and execute the Certification on the original copy. Retain the quintuplicate copy and send all other copies to the Division of Industry Operations (PD-200), War Production Board, Washington, D. C. Where space on the form is not sufficient to furnish the information required or additional relevant information, attach supplemental typewritten statement in quadruplicate. Applicant must be owner or lessee of site of proposed project.

DO NOT FILL IN — Serial No. .... Primary Industrial Branch ....

Instruction No.	To Be Answered Below by Applicant	Instruction No.	To Be Answered Below by Applicant
1	Name of applicant.	11	State estimated completion date of project.
2	Address of applicant.	12	State estimated cost of project, exclusive of site.
3	Location of project.	13	How is project being financed?
4	Have you applied for a Government Certificate of Necessity? If so, identify complete reference.	14	If project will increase manufacturing facilities, state— (*a*) What percent of your total current business consists of orders rated A-10 or better? (*b*) What percent of your current business, limited to the product(s) to be produced by the project, consists of orders rated A-10 or better? (*c*) Pattern of rated orders referred to in paragraph 14 (b), for example: 7 percent—A-1-a; 10 percent—A-2; 30 percent—A-5; etc.
5	Describe project in sufficient detail for complete identification, including— (*a*) Number of buildings. (*b*) Type of construction of each building.	15	Explain in detail what consideration has been given to— (*a*) Temporarily using other available facilities (as vacant building). (*b*) Reconditioning existing facilities. (*c*) Increasing productiveness of present facilities (as by working additional shifts or otherwise gaining objectives of proposed project).
6	Describe product or service to be produced by the project for which application is made.	16	Identify and attach evidence (if any) of Federal, State, or local government endorsement of this application.
7	State capacity of proposed project in terms of product or service to be produced.	17	Have you made other or previous application related to proposed project or any part thereof? If so, explain.
8	Explain in detail relationship of such product or service to national defense, public health or safety, or Government-sponsored programs.		
9	Is proposed project— (*a*) A new facility? (*b*) Addition to existing facility? (*c*) Remodeling of existing facility?		
10	Is proposed project under construction? If so, state— (*a*) Date started. (*b*) Percent of completion.		

Instruction No.	Identify Each Statement With Corresponding Instruction Number (shown above)

Form PD-200, designed by W.P.B. to cover all construction, should be supplemented according to suggestions given in this article

3. Steel Plate. Design vessels so that plates from universal and strip mills may be used. Use shear mill plates where necessary to meet ASTM specifications. Avoid the use of steel plate such as can be rolled on only one or two mills. This does not mean, however, that all steel plate should be kept in narrow widths, for if this were done in all cases, mills would be rolling widths too narrow for maximum production.
4. Avoid the use of nickel, Monel, stainless, aluminum, copper, etc., by using glass, tile and other non-metallic linings. Wherein it is absolutely necessary to use these metals, use clad construction.
5. Keep gages of tubes and lining thickness to a minimum.
6. Use galvanized steel nails, bolts, etc., in the construction of cooling towers rather than copper and copper alloys.
7. Use natural rather than forced draft cooling towers where space and operating conditions permit.
8. Consideration should be given to the use of spraying, parkerizing and bonderizing for corrosion resistance.
9. Consider the possibility of bimetallic tubes.
10. Where copper and copper alloys are essential, reduce the copper content as much as possible.
11. Consider the use of plastic type linings in place of rubber and critical materials.
12. Consider the use of glass, porcelain, and carbon in process piping where low pressures are involved. Where alloy steel is essential, reduce the vanadium, nickel, molybdenum and chromium content as much as possible. These alloying elements have been listed in the approximate order of the most critical element first, and substitutions should be made in that order.
13. Following are a list of conservation measures in regard to alloy steels which have been effective in certain chemical plants:

A. The use of cast iron or enamel iron in place of 17 percent chrome for bubble caps.

B. 25-20 chrome nickel for furnace hangers and tubes are being abandoned for 25-12. Further reductions might be made where less severe service is encountered. In one case 18-8 is being used for these parts.

C. 2½ percent chrome, 1 percent moly steel has relatively good strength at 1400 deg. F. At least one company is using this grade in place of 25-12 for those parts not exposed to severe oxidation.

D. Enameled impellers are being substituted for stainless in pumps in certain instances.

E. Redesign of furnaces has resulted in substantial reductions of alloy steel at the same time maintaining same grade.

F. Insuline (pipe) has been developed for use in high-temperature, low-pressure service. It is understood that this pipe is made up of a thin shell of alloy steel with an outside thin shell of carbon steel with a non-critical insulating material between. This is being substituted for solid alloy pipe.

G. In temperatures as low as 150 deg. 18-8 has been specified in certain instances where as it is understood that 3½ percent nickel steel is satisfactory; whereas it may be even possible to reduce the alloy still further by using ¾ percent chrome, ¾ percent nickel, and 1 percent copper, which it is understood, gives a satisfactory impact test at minus 150 deg. F. and can be welded satisfactorily.

H. In one instance of low-pressure, high-temperature work, carbon steel tubing was wrapped with alloy sheet and welded where it was merely necessary to protect against external oxidation.

I. Consideration has also been given to the use of cast refractories together with alteration of furnace designs to eliminate the use of tube supports.

J. In certain instances 17-4-6 chrome-nickel-manganese steel has been used as a substitute for 18-8. It is understood that material of this composition has been rolled in about three mills.

K. The so-called NE (National Emergency) grades of alloy steels have been used as a substitute for SAE alloy open hearth steel by the addition of other alloying elements providing similar properties but requiring less total alloys. Details in regard to these so-called construction steels are available at the American Iron and Steel Institute.

CONSTRUCTION SUGGESTIONS

Assuming that every effort has been made to reduce the plant requirements to a minimum insofar as critical materials and equipment are concerned, that every effort has been made to use second-hand and reconditioned material and equipment, and to shop around to use existing stock, and those frozen by W.P.B., the following are a few suggestions offered to *Chem. & Met.* readers by the Project Rating Unit of the Chemicals Branch of W.P.B. in order to help in getting material delivered to the job:

Steel Plate—Ascertain that the primary purchaser of the steel plate you buy files with the producer Form PD-298, thirty-five days before the month in which the allocation is required. Ascertain that the primary purchaser is advised of the end use by indicating the P-19 number, the rating and the product to be produced. Ascertain that the steel plate is properly classified on PD-298. Group 5A covers aluminum and magnesium, 5B covers chemical projects for items handled by W.P.B. with the exception of synthetic rubber and toluol. 5D covers iron and steel expansion. 5E covers mining. 5F covers petroleum products except synthetic rubber and toluol. 5H covers synthetic rubber and 5I covers toluol.

Only by proper classifications do these requirements come to the attention of the end group concerned. In addition, all urgent tonnage should be called to the attention of the end-product group by special communication. Steel plate should not be requested unless it is required for the month for which the PD-298 is submitted.

Nickel and Alloy Steel—Ascertain that the end use is clearly indicated in all purchases so that it may be passed on by the companies requesting the metal from W.P.B.

PLANT-DESIGN SUGGESTIONS

We are indebted to the Petroleum Coordinator and specifically to Max B. Miller, for the privilege of abstracting some of their suggestions that may find application in other of the chemical process industries.

Steel Tubes—One manufacturer of alloy tubes advised the Coordinator that he had received orders from various petroleum refiners specifying 19 different sets of specifications. Naturally this seriously interfered with the productivity of the tube mill. It was therefore suggested that alloy tubes henceforth be confined to the following general classifications: (1) Low carbon steel. (2) Low carbon steel with ½ percent molybdenum. (3) 2-3 percent chrome steel with ½ percent molybdenum. (4) 4-6 percent chrome steel with ½ percent molybdenum. (5) 7-9 percent chrome steel with ½ percent molybdenum. (6) 18 percent chrome, 8 percent nickel stainless steel. Since seamless steel tubing is essential to the manufacture of bombs, petroleum refiners are urged to use electric welded tubing or butt-welded pipe wherever possible.

Compressors — Because compressors of less than 300 hp. are more readily available than larger units, it is suggested that batteries of these might be substituted for larger single units under certain circumstances. In some instances absorption refrigerating units have been used as an effective means of reducing the compressor load.

Valves and Fittings — Cast-iron valves should be substituted for steel valves wherever possible, particularly in the smaller sizes. The elimination of alloys in valve bodies will help the situation materially. The practice of prefabricating and/or the welding of pipe should be carried to the limit.

Pumps—Some pump manufacturers have received orders for more pumps than they can deliver according to schedule. At the same time other companies could take on greater commitments if the orders were placed with them.

Small Items — The Coordinator's office recently received a number of complaints because of the inability of a single manufacturer to deliver a particular type of gasket. There were many other manufacturers who could supply suitable gaskets immediately. Because such minor items can and do hold up the completion of various major projects, the Coordinator urged that the work of manufacturing be spread through as many plants as possible so that the full productive capacity of the country may be utilized.

Water-Supply Lines—One refiner recently applied for priority in fittings to complete a 54-in. cast-iron water-supply line for which the pipe had already been delivered. He was told that hereafter reinforced concrete pipe should be used wherever possible. This suggests wider use of masonry for steel in other applications. For example, brick or concrete stacks are satisfactory where suitable foundations can be laid.

Plant Design—Another severe bottleneck in completing the petroleum industry program is in connection with the designing and erecting of plants by engineering and construction companies. Rather than having each installation "tailor-made" to its individual pattern of charging stock, yield and product requirement, the O.P.C. points out that plants previously designed for other installations should be utilized wherever possible, even if it means the sacrifice of some minor, particular, isolated requirement of the individual refiner.

In general, the builder should work in close cooperation with the construction branch of the W.P.B. and the end-product branch in order that the construction may be harmonized to the greatest possible extent with the general war effort. It is highly important that both these groups be kept in constant touch with construction progress, preferably, providing them with construction schedules.

Reprints of this 8-page report are available at 25 cents per copy. Address the Editorial Department, *Chem. & Met.*, 330 W. 42nd St., New York, N. Y.

Machinery, Materials and Products

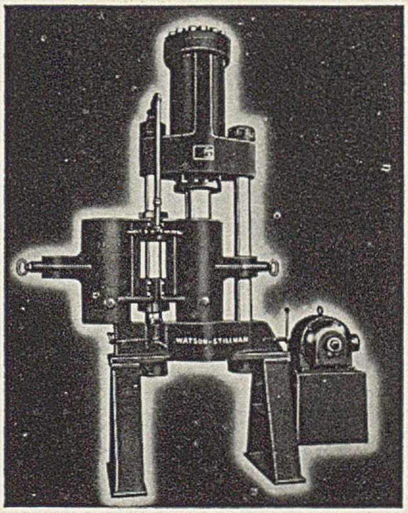
Belt Conveyor Idlers

ENGINEERS OF the Industrial Division, Continental Gin Co., Birmingham, Ala., have recently developed a streamlined belt conveyor idler with several improved features. Idler rolls of all types are easily removed from supporting brackets by simply lifting them out. This can be done with the conveyor in operation. All rolls are made in 4, 5 and 6 in. diameters of either cast iron or steel and are equipped with anti-friction bearings. Grease seals are all-metal labyrinth type, having 5 passes with the inner members protected from damage by a malleable iron nut. These seals prevent both dirt and water from getting into the bearings. Supporting brackets are made of high-grade malleable iron and are amply ribbed for strength. Brackets are jig welded to inverted angle base or to channel bases. This construction gives a one-piece unit in a simple rigid design.

Hydraulic Straining Press

A 200-TON hydraulic straining press, manufactured by the Watson-Stillman Co., Roselle, N. J., and illustrated on this page, strains or filters fluids under a pressure of 2,000 lb. per sq.in. The machine has two cylindrical containers, each 10 in. in diameter and 33 in. deep, mounted on a swinging arm so that one may be filled while the press strains material from the other. The press is completely self-contained, including 20 hp. motor, 18 gal. per min. pump, and oil tank. The entire unit stands 14 ft. high, weighs 15,000 lb. and requires 5 ft. by 3 ft. of floor space. Control is by a single, lever-operated valve. The main ram has a 33-in. stroke that operates in a double-acting cylinder. Two container lifting cylinders facilitate swinging of the containers between loading and straining operations.

200-ton hydraulic straining press



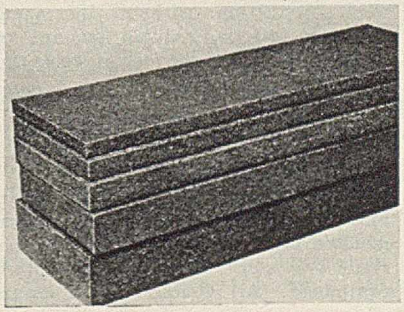
Oil-Immersed Starters

A LINE OF oil-immersed starters incorporating design features which facilitate installation, service and operation, has been announced by the Industrial Controller Division of the Square D Co., 4041 N. Richards St., Milwaukee, Wis. Easier installation is provided through use of a cast head with a wiring manifold which permits conduit entrance from five directions. A removable cover plate facilitates threading of the bare wire through an insulating spacer above the oil bath. The welded seam tank is designed for a minimum quantity of oil and a large oil-level gage provides quick, clear visibility. Track-type guides prevent splashing or accidental collision with the starter panel while the tank is being raised or lowered. Either hand or automatic reset relays are available. Two kinds of oil-immersed inclosure construction are available; the first corrosion-resisting and the second explosion-resisting for Class 1, Group D hazardous locations. Both can be furnished with either Class 8537 line voltage starters, combination starters, or reversing starters, or with Class 8810, two-speed starters.

Mineral Wool Board

A MINERAL WOOL board type of insulation for cold storage has been introduced by the Building Materials Division of the Armstrong Cork Co., Lancaster, Pa., as an addition to the company's line of low-temperature insulation products. The new insulation is a non-priority material and is available for all kinds of installations. The material, illustrated on this page, has been proved in more than 200 installations within the past six months. It equals or exceeds Federal Specification HHM-371 for board or block form insulation, having a thermal conductivity ranging from 0.31-0.33 at 90 deg. F.

Mineral wool board insulation



CHEM & MET PROCESS EQUIPMENT NEWS

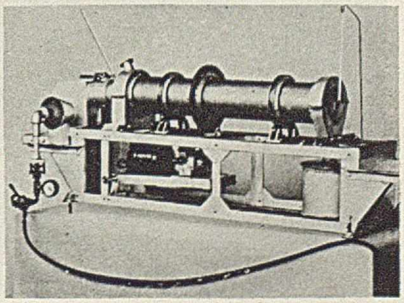
The new material has good moisture resistance, is self-supporting and will stay permanently placed without sagging, settling, shrinking, swelling or warping. It is also free from any liability to rot, mold or harbor vermin. Manufactured in board size of 12 in. x 36 in., and thicknesses of 1 in., 1½ in., 2 in., 3 in. and 4 in., the mineral wool board is applied essentially the same as corkboard. Erection in hot asphalt with multiple layer construction is recommended.

Experimental Rotary Dryer

THE C. O. BARTLETT & SNOW Co., Cleveland, Ohio, has recently introduced a small-size rotary dryer suited for experimental and research work in laboratories and for student instruction in technical schools and colleges. The unit, illustrated on this page, has a cylinder 6 in. in diameter by 36 in. long, fitted with internal feed and lifting flights. The cylinder is carried on a pair of steel riding rings, supported on trunnion rolls and is rotated with a girt gear and sprocket drive. Rotating speeds vary from 2.06-4.92 r.p.m.

Heat for drying is supplied by burning any of the standard bottle gases. Air temperatures range from 110-800 deg. F. and air volumes may be regulated up to about 100 cu.ft. per min. The heating unit is easily transferred from one end of the dryer cylinder to the other, permitting the dryer to be

Laboratory rotary dryer



used in either parallel or counterflow operation. The whole apparatus can be set for any slope to the horizontal by turning jack screws.

Cork Substitute

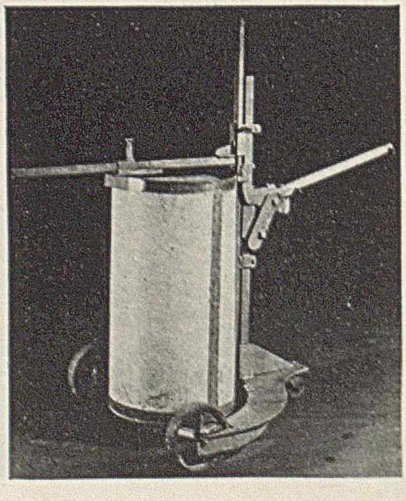
PRODUCTION BY Owens-Corning Fiberglas Corp., of its new asphalt enclosed Fiberglas board for low-temperature and roof insulation releases this country from dependence upon cork for such insulation. The new product is expected to replace cork in food refrigeration and also in industries where cold processing of materials such as oils, chemicals, rayon, etc., requires close control of temperature.

Fiberglas AE board is made in the American standard size for refrigeration insulation (12 in. by 36 in.) and in thicknesses of 1, 1½ and 2 in. It is made of glass fibers, compressed to a density of 6 lb. to the cu.ft. and completely enclosed in a sheath of durable asphalt with a high melting point. Its heat conductivity is 0.265 B.t.u. per sq.ft. per hr., per deg. F., per inch thickness at a mean temperature of 60 deg. F. When exposed in a humidity cabinet of 70 deg. F. and 65 percent relative humidity, the moisture pickup from a previously dry condition is 0.064 percent by weight. The insulation has high resiliency, and shows almost complete recovery in 5 minutes after loading to 1,728 lb. per sq.ft. The board will withstand walking on in floor and roof applications.

Drum and Barrel Carrier

THE NEW Ernst Drum and Barrel Carrier has just been announced by the Ernst Magic Carrier Sales Co., 1456 Jefferson Ave., Buffalo, N. Y. This new model, shown in an accompanying illustration, is designed to handle light wood, fiber, paper barrels, and "one trip" light gage steel containers with or without chimes. The capacity of the unit is 800 lb. and it will accommodate drums and barrels from 14 in. to 24 in. diameter. Three-wheel construction automatically balances the load for safer and easier moving of containers and operation is so simple that one man can take care of it. Another feature is the straight, vertical lift of the barrel from the floor to prevent any flowing over of contents from open-head containers.

Drum and barrel carrier



Time Schedule Controller

THE NEW Taylor Fulscope time schedule controller, developed by the Taylor Instrument Cos., Rochester, N. Y. maintains temperature, pressure, flow or liquid level according to a predetermined time schedule. It is possible to automatically and precisely repeat the process as many times as desirable.

Both cam and chart are individually mounted and conveniently located for instant visual comparison. Among the improved features of the new unit are: friction drive cam assembly which permits rotation of the cam without loosening any locking means; improved means of resetting one cam without disturbing the other in an instrument with two complete control mechanisms; each cam capable of operating 1-4 air valves, micro-switches or both for the actuation of any external mechanisms and to do this automatically in any desired relation of one to the other; automatic return of the cam to the starting position. An optional feature is the Interrupter Climber which allows flexibility to both the rise and the holding periods of the process under control. This allows use of a very fast cam clock for a rapid rising period, but reduces the speed of the clock to increase the length of the holding period. The rising period, the holding period, or both, may be increased as much as 6½ times normal.

Welding Technique

A NEW TECHNIQUE in fillet welding by electric arc process, called the "Fleet-Fillet" technique, has been announced by the Lincoln Electric Co., 12818 Coit Road, Cleveland, Ohio, after extensive study and research by the concern's engineers and research technicians. The new technique, which permits up to 100 percent faster fillet welding, made possible in one typical case an arc speed of 65 ft. per hr. for welding a ⅜ in. horizontal fillet as compared with 30 ft. per hr. using conventional procedure. The new technique makes possible faster weld production without increasing operator fatigue, reduces amount of welding electrodes per foot of weld, and lowers welding costs.

Overhead Traveling Crane

EFFECTIVE IMMEDIATELY, the Harnischfeger Corp., Milwaukee, Wis., announces that Trav-Lift cranes will include two added features of standard equipment. All double I-beam cranes employing a motor-driven trolley will be equipped with a drag brake on the trolley. All cage-controlled "Trav-Lifts" will be furnished with a foot gong. Formerly these accessories were available on special order only. P & H Trav-Lift cranes are made in capacities up to 15 tons and are suited for intermittent service and for supplementary usage with the large overhead traveling cranes also manufactured by the concern.

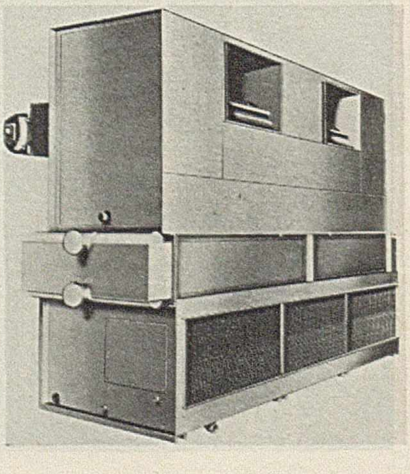
Solvent Extraction System

IT HAS BEEN recently announced that the Wolf Co., Chambersburg, Pa., has taken over the manufacture of equipment for the Kennedy continuous solvent extraction system. This method of continuous solvent extraction offers an improved process for the production of oil, fats, and greases of various types. It is also adaptable to many leaching and extraction problems other than solvent extraction and has shown a marked saving in the extraction of water-soluble constituents such as natural dyes and tanning extracts. At the present time, experimental tests are under way on the application of the Wolf "Kennedy" extraction system on tung nuts for the production of tung oil.

Quenching Oil Cooler

A NEW QUENCHING oil cooler applicable for a variety of process liquids as well as for metallurgical processing, has been announced by the Trane Co., LaCrosse, Wis. The unit, illustrated on this page, utilizes the atmospheric evaporative principle and is ordinarily applicable where the use of water is uneconomical or impractical, where water temperature is too high, or where it is not necessary to maintain quenching bath temperature below 100 deg. F. The unit is self-contained and can be placed inside the area in which the quenching oil cooling operation is conducted. It can be suspended from the truss structure of the building, thus conserving floor space. Other mechan-

Quenching oil cooler



ical features include a rigid angle iron framework with heavy gage side sheets, a light-weight, high-heat transfer type of oil cooling coil; ample size squirrel cage fans, mounted on a heavy ground and polished steel shaft; and a heavy gage steel spray water tank and angle supports. A pump circulates oil from the quenching tank through the cooler and back to the quenching tank. Any desired temperature not lower than 100 deg. can be maintained automatically.

Disconnecting Switch

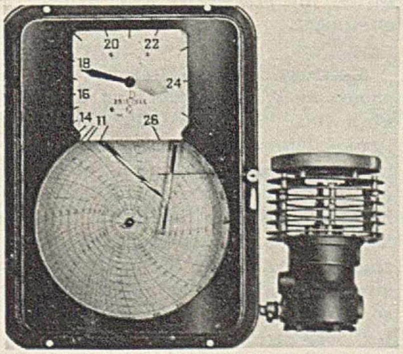
A NEW HIGH-PRESSURE contact heavy-duty disconnecting switch has been announced by Delta-Star Electric Co., Chicago, Ill. This new 3,000-amp., 23 kv. hook stick-operated switch has high-pressure silver to copper contacts at both blade ends. The design embodies a straight line current path with current carrying parts of hard drawn copper, thus eliminating castings. Rugged locks and a pressure releasing device are standard equipment. Clamp type lugs for IPS tubing can be furnished or switch pads for square tubing or flat bars. These Type B2-P switches in capacities from 2,000-6,000 amp. and up to 24.5 kv. ratings are available.

Radiation Pyrometer

A NEW RADIATION pyrometer, known as the Pyrovac, has been developed by the engineers of the Bristol Co., Waterbury, Conn. This new instrument, illustrated by an accompanying cut, is designed for recording, indicating, or automatically controlling temperatures in furnaces and kilns above 900 deg. F. The temperature-sensitive unit or radiation head is mounted on the outside of the furnace out of the hot zone where it picks up heat rays emitted from the object under measurement, thus registering its surface temperature.

The Pyrovac pyrometer is intended for use in measuring and automatically controlling temperatures that fall into the following classifications: (1) high temperatures out of the range of the thermocouple; (2) temperatures for which rare-metal thermocouples are used; (3) surface temperatures and the temperature of the work itself rather than furnace or kiln temperatures surrounding the work; (4) where the object is moving, is inaccessible, or where there are space limitations.

Radiation pyrometer



Concrete Pier Form

A NEW FAST and cheap method of forming concrete piers has recently been announced by Sonoco Products Co., Hartsville, S. C. The Sonoco laminated spiral wound tube for concrete pier forms has been thoroughly tested and approved by engineers.

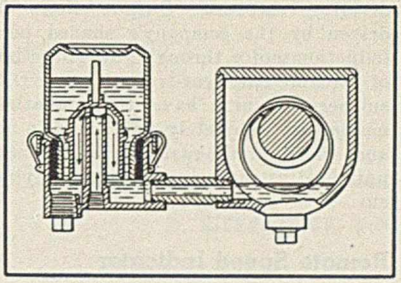
The form consists of made-to-size, spiral-wound laminated paper tubes with the inside oil treated. The units are available in lengths up to 24 ft. and inside diameters of 9 in., 11¼ in., and 13½ in. The tubes are simply cut to length on the job by hand or power saw in a matter of seconds and the form is tacked into upright position. Concrete is then poured into the form. Forms are easily stripped off after piers set up, although this is not necessary as they will eventually slough off if exposed to moisture. An inexpensive stripping tool has been devised for this operation. It is claimed that the forms result in extensive labor and material savings.

Intercommunication System

DESIGNED ESPECIALLY to facilitate moving of stations and expansion of the automatic interior telephone system in office and plant layouts, this new telephone announced by Select-O-Phone Co., 1012 Eddy St., Providence, R. I., may be plugged into any terminal box, which requires only a single strand of triple-conductor wire to be run to the Select-O-Phone switchboard. The center of the dial is a code-ringing button which is pressed to code signal where several persons may be served by one telephone, or when using the built-in general call paging circuit. All plug-in telephones are interchangeable. Dialing any number automatically connects to the desired party in a secret conversation. Provision is also included for secret conference among three or more persons. The capacity of the system is from 5-55 lines, with extension possibilities to 100 or more stations.

Constant Level Lubricator

IN ORDER to prevent oil waste and to insure lubrication, the Oil Rite Corp., 3466 S. 13th St., Milwaukee, Wis., has developed a new unit known as the Oil-Rite Constant Level Lubricator. The unit holds a visible reserve supply of oil and releases automatically just as much as is needed to maintain a constant predetermined level of lubrication. The unit, illustrated on this page, is said to insure adequate lubrication at all times and prevent oil waste and the deterioration of material caused by oil throw.



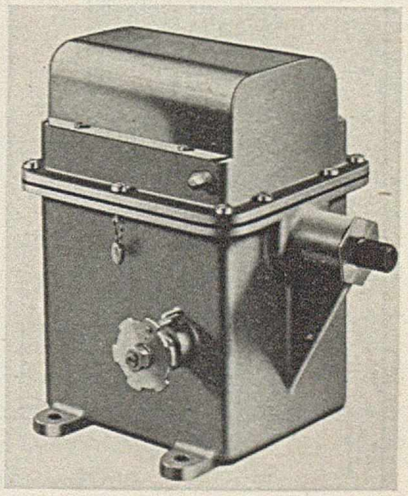
Constant level lubricator

Construction of the lubricator consists of three simple parts. The base is cast of Zamak metal with an integral open air vent extended part way up into the oil reservoir. Over this vent is fitted loosely an inverted bucket or bell. The reservoir proper is a glass dome, sealed to a metal collar by plastic porcelain cement impervious to acids, oils, water and heat. Two spring clips lock the oil reservoir in position. When the reservoir is filled and inverted into position on the base, the lower edge of the inverted bucket determines the oil level that will be maintained. When the level falls below this point, air from the vent escapes under the side of the bell up to the top of the lubricator, permitting oil to flow down until the level again seals across the base of the bell. Oil-Rite constant level lubricators are available in four standard sizes, with capacities of 2, 4, 8 and 16 oz.

Valve Controller

FOR OPERATION of butterfly valves, multiple ratio fuel valves, and regulation of dampers in air conditioning and drying systems, the Barber-Colman Co., Rockford, Ill., has recently announced a new control unit known as the Microtrol. The unit features a high torque proportioning control motor with built-in limit switches and potential

Valve control unit



dividing rheostat. Output shaft is driven by the company's shaded pole induction motor through gear reduction of machine cut, heat-treated gears. Oil-submerged units have the operating mechanism completely submerged in oil and sealed in die-cast cases. The new unit is illustrated by an accompanying cut.

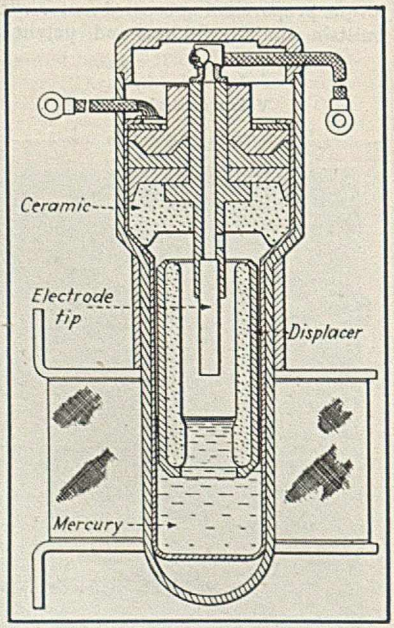
Remote Speed Indicator

A NEW TYPE electric remote speed indicator for use with the concern's variable speed control equipment has been announced by Reeves Pulley Co., Columbus, Ind. This instrument gives a reading in terms of "speed setting" of the output shaft of the Reeves drive. The indicating meter is really a voltmeter with a long, 4-in. arc scale built integrally with a pair of electric control push buttons in a cast iron housing. The indicating system is made in two parts; one consisting of the push button and indicating meter, and the other a potentiometer mechanism mounted on the drive near the shifting screw. The mechanism is actuated by rotation of the shifting nut or movement of the sliding base, and such movement is transmitted to the potentiometer which varies the voltage impressed upon the indicator. Power supply for the indicator is self-contained in the form of a single standard size flashlight cell.

Blackout Relay

A NEW BF blackout relay which works under a hydrogen quenching atmosphere has been announced by Durakool, Inc., 1010 N. Main St., Elkhart, Ind. Principles of the relay are shown in an accompanying illustration. It is claimed that no arcing, pitting or burning of the electrical contact members can occur and no moving part other than the liquid and its float are involved. Built especially for war-time purposes, the unit is designed to take unusual knocks and hardships without failure. The iron displacer is lined with ceramic and normally floats on mercury. When current is passing through the solenoid, the displacer is pulled down, thus raising the mercury level and bridging the electrode to the metal shell. The tube is filled with an inert gas under high pressure. The unit is non-explosive, quenched arcing and highly shock-resistant.

Principles of the blackout relay



Equipment Briefs

A NEW LINE of temperature measurement colors, known as the Thermindex Colours, has been announced by J. M. Steel & Co., Ltd., Kern House, 36-38, Kingsway, London. The method is of particular interest to the metal industries, as it gives temperature distribution over a heated surface instead of the temperature at any specific point, such as usually would be obtained with the more usual measuring devices. The colors are offered in the form of a paint suitable for direct application to practically any surface by brushing or spraying. When the temperature of the treated surface is raised, the original color of the pigment changes sharply at a definite point and the new color persists after the surface has cooled down. Colors covering a wide range of temperatures are available.

A QUICK-HARDENING iron cement for patching concrete floors has been announced by Smooth-On Mfg. Co., 570 Communipaw Ave., Jersey City, N. J. The new product hardens quickly and adheres firmly to the surfaces with which it is in contact. It has an iron base and is wear-resistant as well as dustproof, oilproof and waterproof. Patches of the material harden over-night and become stronger with age.

THE LINCOLN ENGINEERING Co., 5701 Natural Bridge Ave., St. Louis, Mo., is now manufacturing forced-induction pumps known as the "Pile Drivers". These pumps are designed to dispense heavy viscous materials such as sealing compounds, sound deadeners, insulating materials, putty, heavy lubricants and other substances too heavy and solid to prime in any other type of pump. The units do away with the old stuffing-by-hand and putty-knife and paddle methods. The pump is available in single or 2-stage models and two sizes can be furnished. The single-stage unit is for use where pulsation in the flow of material is permissible, while the 2-stage unit has a pulsation eliminator. Delivery of material is controlled by a hand-operated shut-off valve at the outlet.

A NEW technique for the colorimetric determination of pH has been developed by R. P. Cargille, 118 Liberty St., New York, N. Y. Solutions of known pH made by dissolving a tablet are applied to the test paper to bring out on the paper the color for any half-units from a pH of 3-11. The colors are used for reference to judge the pH of the sample and it is claimed that comparisons made with these reference colors are more accurate than those made with color charts. The unit is designed for control tests in the plant by unskilled workmen and for quick, preliminary tests in laboratories.

A NEW SPARKPROOF, static-proof truck and caster type phenolic molded canvas wheel, called the "Formica Staticon," has been developed by Divine Bros. Co., Utica, N. Y. The wheel is designed for proper dissipation of static electricity that builds up in factory trucks and is recommended for use in ordnance plants, shell loading factories, and other places where sparks are a hazard. A laminated canvas tire is impregnated with a colloidal graphite compound which makes an electrical conductor within the fabric itself. The hub material is similarly impregnated with a graphitic compound, the two elements being permanently connected by copper cable molded within the wheel body, thus forming a continuous contact from the truck, through the wheel housing, shaft and wheel to the floor surface. The synthetic varnish introduced into the wheel during the molding process protects the conductive element from moisture absorption. The wheel is fully floor protective, chemically inactive, non-corrosive and quiet in operation. Sizes range from 3-12 in. wheel diameters.

THE NEW "Safront" resistance welder control introduced by the Square D Co., 4041 N. Richards St., Milwaukee, Wis., places all electrically energized parts behind a protective panel, thus eliminating any danger of shock while timing adjustments are being made. The design provides a separate pneumatic timing device for each step of the welding cycle. Timing periods from 3-100 cycles are accurately obtained simply by turning a wheel. A separable connector permits panel removal without disturbing external connections. Both timers and relays can be serviced with standard tools. Eighteen NEMA standard types of "Safront" weld and timers, plus a wide range of accessories, fill practically any welder requirement.

A MIDGET daylight lamp has been designed by W. A. Taylor and Co., 7300 York Road, Baltimore, Md. The unit is useful in making colorimetric determinations, and although it was originally designed for making determinations at night or in dark places, it has been found to be ideal for all routine testing. The Comparator base sits on the shelf at an angle of 45 deg. so that in making readings the operator looks directly in the slot.