CHEMICAL & METALLURGICAL ENGINEERING

ESTABLISHED 1902 S. D. KIRKPATRICK, *Editor*

JANUARY, 1942

Chemical Industry in the War

Careful reading of Bernard M. Baruch's recent book on industrial mobilization ("American Industry in the War," Prentice-Hall, 1941), serves as a timely reminder of the vital part played by chemicals in our first World War effort. As early as April 1917 a chemicals committee had been formed under the raw materials division of the old Council of National Defense. When, later, the War Industries Board was organized, Mr. Baruch insisted that the chairman of this chemicals committee should serve as his technical advisor and become an official member of the Board. That man was Leland L. Summers, a consulting engineer, who, since 1915, had been prominently identified with the purchase of chemical munitions for the Allied governments. During all of the Board's activities, Mr. Summers sat as one of its eight members, sharing industrial representation with only Mr. Replogle, the steel administrator, and Mr. Peek, commissioner of finished products. Mr. Summers also insisted on remaining the administrative head of both the explosives and chemical divisions—the former directed by March F. Chase and the latter by Charles H. MacDowell, ably assisted by approximately twenty sectional chiefs drafted from the executive ranks of the various chemical industries.

This much of history is reviewed here to point a contrast and perhaps as the basis for some questions about our representation in the current war effort. Obviously chemicals are no less important now than they were twenty-five years ago, although it is true that today we are much better prepared because of our highly developed chemical industry. But does that mean there is no longer the need for adequate and aggressive representation of our industry by some of its top executives serving on the various planning boards that are now directing the war program? Must chemicals continue to be subordinated to other industries, shrouded with mystery and misunderstanding? Perhaps such questions may seem ungenerous or unfair to the many patriotic, competent and hard-working technologists who have ably represented chemical industry in OPM and OPA. Certainly that is not intended. Rather, these questions reflect an impression that is rather widely prevalent in chemical industries. Many people are beginning to ask, perhaps inadvisedly, why the names of the members of the various chemical advisory committees have not been made public, why the organization and procedures of the chemical units are not better understood, why everything "chemical" is a military secret which can be shared only with those in the inner circles?

Tanks, planes and battleships are units that can be readily understood and visualized by anyone. They are made largely of metals and there seem to be no secrets about war requirements for steel and copper, aluminum and magnesium. Our needs for uniforms, shoes, and similar supplies are a simple matter of arithmetic. But when it comes to smokeless powder and TNT, or even their basic chemical ingredients, there is little or nothing known except to those within the charmed circles. Yet if the United States is soon to put the victory program into full operation, there may well be some advantage in carrying information of this sort to engineers and managers of chemical enterprises all over the country. Certainly the expanding needs for additional personnel, as well as production facilities, would seem to argue in favor of more general release of such information as would not be of help to our enemies.

Our big job in 1942 is to achieve a full mobilization of American chemical industry. In the words Donald Nelson addressed to a group of business-paper editors on December 19, this "means drastic changes in our existing industrial economy. We must now think only in terms of out-producing a powerful enemy; and anyone who under-estimates the ability of the enemy to produce is only kidding himself." This job of converting chemical industry into a great, efficient war machine is one that calls for the united effort and support of all of us, whether in small companies or large corporations, whether now producing war materials or essential civilian goods.

American chemical industry served with great distinction in the last war, despite the fact that it was young and inexperienced. So far in the present effort it has done its share and has set fine records for efficient production as well as whole-hearted cooperation with the government. But we can and must go a lot farther and faster. We need to mobilize every chemical resource in manpower, materials and plant facilities. We need strong and vigorous leadership.

BILLIONS FOR DEFENSE

As of January 1, 1942, according to the OPM Bureau of Research and Statistics, there have been approximately 71 billion dollars of appropriations, contracts and authorizations in the defense program. The largest single item in the tabulation is for ordnance, including naval ordnance, which accounts for 16.5 billions or 23 percent of the total program. Other munitions add 3.5 billions, stockpiles, equipment and supplies, 6.6 billions; so that at least 37 percent of our money has been earmarked for materiel of direct concern to chemical engineers. Just what proportion of this staggering total is represented by chemicals and explosives, as such, has not been shown, but we would estimate it as at least a fifth of the total for these three items.

The same Bureau reveals that from the beginning of the defense program through September 30, 1941, industrial facilities for defense financed by the government and privately, totaled $5,260,463,000. Here chemicals, including explosives, accounted for 13.8 percent, petroleum, coal and gas, 0.7 percent, and ammunition, shells and bombs an additional 16.2 percent. Again it seems safe to estimate that chemical engineering construction has accounted for at least a fifth of the industrial facilities for defense. This figure of approximately a billion dollars is about ten times the normal building program in our field. And it must be greatly increased as the victory program swings into full operation.

So, with $15,000,000,000 already appropriated for chemical munitions, with at least another billion in new defense plants, and more in the offing, "billions for defense" is not just an idle boast. It's chemical industry's biggest order for 1942 delivery.

ADJOURN REFORM

Reform has not been adjourned for the war. One would think that official Washington would lay aside its hobbies and get down exclusively to war business. Unfortunately this is not the case. Complete licensing of explosives producers, distributors and users has begun. The government is taking over more power properties nominally for defense, actually to get operating control. The President has named a new patent board to figure out how the patent system can be revised. An obvious objective is to get more control of patents, not to make patents more the servant of industry and the public. And Secretary Ickes outdoes himself in reform-

Volume 49—Chemical & Metallurgical Engineering—Number 1

Chemical & Metallurgical Engineering is the successor to *Metallurgical & Chemical Engineering*, which in turn was a consolidation of *Electrochemical & Metallurgical Industry* and *Iron & Steel Magazine*, effected in July, 1906.

The magazine was originally founded as *Electrochemical Industry*, in September, 1902, and was published monthly under the editorial direction of Dr. E. F. Roeber. It continued under that title until January, 1905, when it was changed to *Electrochemical & Metallurgical Industry*. In July, 1906, the consolidation was made with *Iron & Steel Magazine*, which had been founded eight years previously by Dr. Albert Sauveur. In January, 1910, the title was changed to *Metallurgical & Chemical Engineering*, and semi-monthly publication was begun Sept. 1, 1915. On July 1, 1918, the present title was assumed and weekly publication was begun Oct. 1, 1919. Monthly publication was resumed in March, 1925.

Dr. E. F. Roeber was editor of the paper from the time it was founded until his death on Oct. 17, 1917. After a brief interim he was succeeded by H. C. Parmelee. Ten years later, Nov. 1, 1928, Mr. Parmelee assumed other responsibilities in the McGraw-Hill Publishing Company and Sidney D. Kirkpatrick was appointed editor.

The present editorial staff of the magazine comprises, in addition to Mr. Kirkpatrick: James A. Lee, managing editor; H. M. Batters, market editor; T. R. Olive, associate editor, J. R. Callaham and L. B. Pope, assistant editors. R. S. McBride, William E. Becker, E. S. Stateler and Earle Mauldin are editorial representatives in Washington, D. C., on the Pacific Coast, in Chicago, and in Atlanta, respectively.

effort as he takes over his duties as solid fuels czar and greatly extends his disciplinary rules over the petroleum industry. Using wartime authority for reform seems to be a hobby of the Interior Department.

SYSTEMATIC VS. SPORADIC SAVINGS

Most people, especially since December 7, don't need to be told why they should buy more defense bonds. We know it is a patriotic duty as well as a personal privilege to invest our savings in the future of America. But some of us put it off, or contribute sporadically, for the simple reason we have no definite plan of procedure. If that is the case in your organization, you will do well to investigate the voluntary pay-roll allotment plan that is now being widely adopted by small as well as large companies in our industries. Remember that France left it to hit-or-miss—and missed. Let's hit and hit hard, week by week, month by month, until our combined efforts result in American victory.

WASHINGTON HIGHLIGHTS

ALLOCATIONS proceed apace. Already there are 15 or 20 commodities you can't own or process without Uncle Sam's OK. Most of them are imported strategics like rubber, tin, and chromium. But the equivalent procedure will apply to more and more chemicals as mandatory allocations replace priorities. What has already happened to chlorine, methanol and ferro-alloys shows what to expect for other chemicals.

SABOTAGE, incendiarism and enemy air raids, but the greatest hazard of them all in chemical industry, is sabotage. Read in this month's *Chem. & Met.* report (pp. 101-8) the best advice the editors have been able to glean from the Office of Civilian Defense, the Chemical Warfare Service, the Federal Bureau of Investigation and numerous other sources.

SUBCONTRACTING in most chemical manufacturing is not so easy. But Washington expects more process industries to share in the defense load. This means that small plants, even those not commonly doing process work of the needed sort, can make their contribution to defense production. Such operators will not be a permanent part of our industries. But they can help now when even a small step in advancing goods toward completion for military use is desirable, in fact, necessary.

CHEMICAL PROMOTERS are not wanted in Washington. Direct action by executives of process industries in dealing with government officials is preferred. There is a place for the Washington representative in legal, tax, and technical matters. But he cannot safely, particularly at this time, be substituted for executive action by those who can speak directly on company policy. Government officials prefer to deal with career members of a staff, not temporary exponents of some "cause."

WASTE ELIMINATION, especially in use of metals and certain chemicals, is most vital. Even where it takes more labor, or causes increased cost, economy in consumption is sought. The United States had suddenly achieved an economic relationship like that which has long prevailed in Europe. This temporary situation means that we can waste labor to save material. We must pursue a policy of ruthless economy on materials. Nor must we lose sight of the fact that there are opportunities for simplification of specifications and the elimination of costly frills and excessive refinements.

PRICE REGULATION will come. In general, it will apply principally to consumers' prices. Thus, those industries like the fertlizer manufacturers, who sell to ultimate users, may be the first to be pinched. But also there will be many more specific industrial-commodity price-control orders such as those recently issued for alcohol, butanol, acetone, and glycerine. As these price controls develop it will be particularly important for engineers and executives of the chemical industries to know and identify clearly all new elements of cost. Generally speaking, only such *new* costs, especially those imposed by war conditions, will be assumed to justify price advances.

TAXES to supply one-third, perhaps more, of needed war money will be the ambition of Congress. This means that some of the extreme ideas previously reported as mere proposals of Washington come closer to reality week by week. The first tax law of 1943 may actually double the tax collector's "take" in many industries.

WAR CONTROLS must be recognized. Speed-up is expected. Demand for more continuous plant operations is certain. Better scheduling of hours of work, as in the Gray plan described on page 86, is worthy of immediate study. But with all the pressure of speed up, we must still watch out for the vital element of safety of plant and personnel. That alone can take precedence over increased output in these times.

U. S. MINISTRY OF SUPPLY, long delayed, is now in the making. Evidence that the government is becoming increasingly impatient with present procurement policies is accumulating. The President's demand for a $50 billion per year spending program may sway the decision toward civilian control of purchasing. With needs mounting on such a grand scale, it's almost safe to say that chemical industry can't possibly plan for too much production of military necessities. Not so, of course, for civilian goods.

TANK CAR shortages are expected. Obviously there will not be as many tankers as needed for petroleum or molasses carriage. Even more obviously, the burden on rail transportation by increased business is already overloading our liquid-carrying facilities. This means that economy in tank car usage, prompt unloading, quick return, and simply doing without, will all be necessary. As statistics are issued regarding tank car supply, it will be important to note that the Association of American Railroads claims that a car is idle when it is not actually on their rails and moving. Hence, a tank car that is rendering full service, is classified as idle for a substantial percentage of its time, with weird statistical results on occasion.

Our Enemies, Chemically Speaking

KARL FALK, *Fresno State College, Fresno, Calif.*

Chem. & Met. INTERPRETATION

Because the present World War is being fought in the industrial as well as the military sphere, this timely review of the economic and technical positions of the Axis chemical industries is distinctly in order. It has been prepared for *Chem. & Met.* largely by Dr. Falk, who formerly represented this magazine in Europe. While it clearly shows that we have formidable opposition in prosecuting both the war and the subsequent peace, nevertheless, the tremendous preponderance of basic raw materials, plants and personnel available to the non-Axis powers should more than counter-balance the initial advantages of close collaboration during almost a decade of chemical preparedness by our enemies.—*Editors.*

Germany, Italy and Japan, poor in resources but rich in ambition, have organized their industries under government direction to make the greatest possible use of available raw materials while trying to develop militarily independent and blockade-proof economies. In the Reich, lessons from the first World War were carefully studied and this accounts for the emphasis placed on synthetics even before the outbreak of this war. German chemicals were also used as an important medium of exchange to obtain on world markets reserve supplies of vital materials in which the Reich was deficient. This was possible since Germany's normal chemical exports are two to three times chemical imports. The Axis partners, Italy and Japan, normally import more chemicals—at least raw materials—than they export.

Before the outbreak of World War II, in *total chemical production* the Great Powers ranked as follows: United States, Germany, United Kingdom, France, Japan, Italy, and the U.S.S.R. United States accounted for two-fifths of world chemical production, while Germany supplied less than one-fifth. In *world trade* in chemicals, however, the order in 1938 was: Germany, United States, United Kingdom, France, Japan, Italy, U.S.S.R., with the Reich supplying between one-fourth and one-third the total and the U.S. one-sixth. The United States has been the world's largest chemical importer, and Germany the world's largest exporter.

Assuming that exports represented roughly a surplus over domestic needs and that raw materials were available—which is not always the case—and that war damage no more than cancelled out new plant construction since 1938, a breakdown of leading chemical traders into Anti-Axis, Axis, and countries accessible to the Axis (with important reservations for Switzerland's unique position, and for occupied parts of the U.S.S.R.) would be roughly as shown in Table I.

This breakdown, of course, fails to show the importance of British Empire and Latin American chemical raw material sources, but it also does not include the growing production of Scandinavian and Balkan countries which are accessible to the Axis.

GERMANY'S STRONG POSITION

Germany, as the largest Axis chemical manufacturer, bases its production chiefly on available raw materials, coal, lignite, potash, limestone, salt, wood, magnesite, and other raw materials. The Reich normally depends on foreign sources for vegetable oils, naval stores, crude drugs, phosphates, natural rubber, borax, sulphur, pyrites, carbon black, natural oil and petroleum, and other less important items. Some of these have now been successfully replaced by substitute or alternate materials. Germany's leading chemical exports normally are coal-tar dyes, potash, medicinals, ammonium sulphate, nitrogenous fertilizers, pigments, paints and varnishes, synthetic resins, insecticides, and other agricultural and industrial chemicals.

In certain chemicals the Reich is the world's chief producer. Of the 1939 world output of approximately 200,000 metric tons of dyestuffs, Germany accounted for the largest share, exporting about one-third of its production and supplying 56 percent of the total international trade in these products. In normal years the Reich exports 50 percent and more of its dye output.

Of the world's 3 million metric ton output of nitrogen in 1938-9, German synthetic ammonia plants with a capacity of 1.4 to 1.5 million tons supplied the largest share. Most of the Reich's production of synthetic ammonia is from brown coal water-gas and is manufactured in I.G. plants at Leuna and Oppau near Ludwigshafen.

Germany is also the world's largest producer and exporter of potash, having strengthened its monopoly still further through recent incorporation of 11 Alsatian potash mines. In 1937 Germany produced 62 percent and France 15 percent of the world's potash.

Although figures are no longer accurate, Germany claims to have been the world's largest producer of aluminum in 1938, with 165,000 tons. In 1939 it produced 210,000 tons or 32 percent of the world output, which has increased considerably since then. Raw materials for this militarily important metal are not found in the

Table I—Foreign trade of principal countries in chemicals and allied products*

	Imports (millions)	Exports (millions)
ANTI-AXIS		
United States	$146.0	$158.5
United Kingdom	117.3	131.7
Canada	38.4	20.5
U.S.S.R. (1937 estimate)	6.7	13.4
Total	$308.4	$324.1
AXIS		
Germany	$84.2	$263.3
Japan	46.1	34.8
Italy	29.5	29.7
Total	$159.8	$327.8
ACCESSIBLE TO AXIS		
France	$64.5	$90.6
Netherlands	55.0	48.6
Belgium	48.4	62.2
Switzerland	24.5	40.7
Denmark	26.6	3.9
Poland and Danzig	14.2	6.1
Total	$233.2	$252.1

*From "World Chemical Developments in 1938," U. S. Department of Commerce.

Reich, but bauxite is available from Hungary and Yugoslavia, France and Italy. Germany is also an important magnesium producer, especially with control of magnesite supplies of Austria the world's second largest producer.

In 1939 the Reich produced 2.8 million metric tons of sulphuric acid, a new peak for Germany caused by increased demands for manufacturing artificial fibers, mineral oils, nitration products, fertilizers and munitions. It also imports considerable sulphuric acid and the raw materials, sulphur and pyrites, from Italy, Spain, Norway, Sweden, and Yugoslavia. Pyrite and iron ore from Sweden, northern France and elsewhere will probably enable Germany to keep up steel production, which was 23 million tons in 1938.

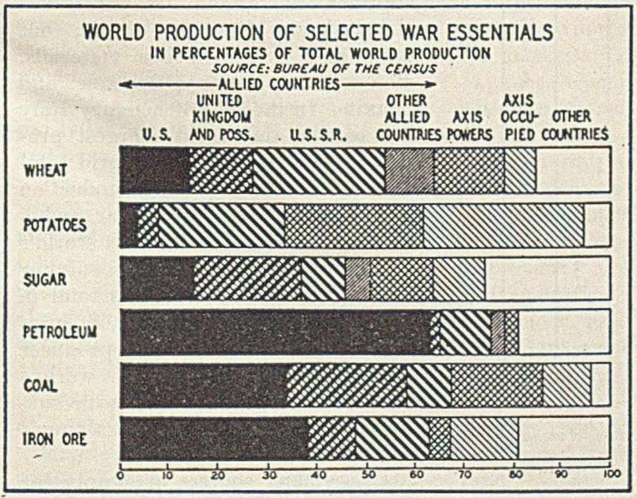
Germany is behind the United States, however, in the output of plastics and rayon, but leads in synthetic rubber, synthetic motor fuels, and staple fiber. Although production of these items has expanded tremendously in the last five years the Reich is still unable to fulfill domestic requirements with synthetic products. Synthetic rubber, chiefly Buna types, accounted for only 40 percent of the rubber consumed in the Reich in 1939. Of necessity, the percentage is probably higher now, and the same ratio would probably hold for synthetic textiles. In 1941, 30 plants in the Reich produced around 30 million barrels of synthetic motor fuels, thereby trebling the 1938 output. In that year, however, Europe consumed 200 million barrels of oil and produced only 75 million itself, not counting Soviet production, little of which was available for export. The rest had to be imported from overseas.

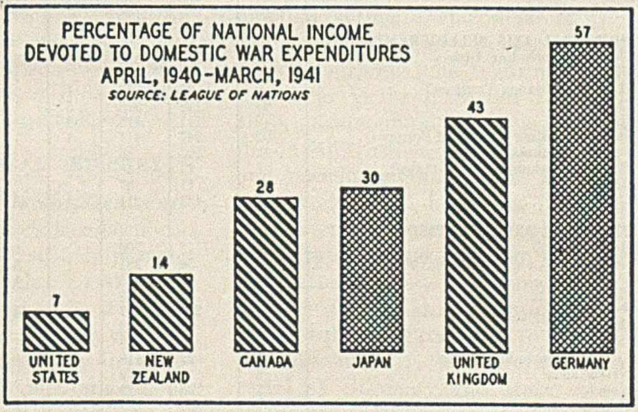
Although the Reich exports superphosphates, it must import phosphate rock. Normally this has come from the United States, but in war time is available from France and Italy. The Reich is far behind the United States in this fertilizer item as well as in output of chlorine and alkalies such as soda ash and caustic soda, needed for manufacture of artificial fibers and other synthetics.

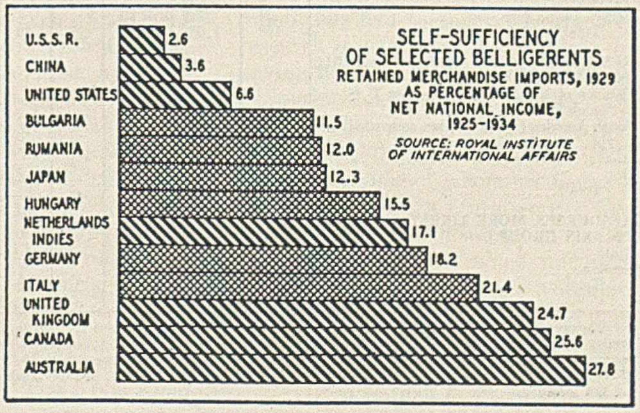
The Reich chemical industry, with a production valued at well over 6,000 million RM per year, ranks among the first five industries in Germany, and accounts for approximately one-fifth of that country's exports. Through the annexation of Austria and most of Czechoslovakia in 1938-9, before the outbreak of the war the chemical industry acquired an additional annual production of 400 million RM, and it is impossible to estimate what share other voluntary and involuntary Axis partners have contributed in the meantime in the chemical field. Poland has considerable capacity and raw materials, and France and Belgium are among the world's leading chemical producers. It must be remembered that conditions are in a constant state of flux, and it would be a mistake to assume these countries as operating at full capacity, while the changing theatres of war and adaptation of production to war time needs has changed the Reich's own production. As far as the other countries are concerned Germany supplies or withholds raw materials as its own needs dictate.

Reich chemical and allied industries, employing over 600,000 persons, have experienced a new boom since the outbreak of the war. Production had reached a new peak in 1939. At the outbreak of the war the publication of all statistical data was discontinued for military reasons. It is known, however, that the output receded in such lines as dyes, paints and pigments, soaps and other consumer goods, while it increased greatly in industrial chemicals required for producing domestic substitute or alternate materials or for the manufacture of munitions and other military needs. Marked gains are reported, for example, in the manufacture of sulphuric, nitric, acetic, and other industrial acids, alkalies, electrochemical products, carbon bisulphide, coal-tar derivatives, and related materials. An indication of the

Men and materials for war, as graphically presented by the National Industrial Conference Board in its *Economic Record* for December 24, 1941. See also Table I on page 82







extent of further production increases since the war started may be taken from the recently published report of the German A.G. Dynamit Nobel, manufacturer of explosives, celluloid, plastics, etc., which announced that in 1940 production had been 50 percent higher than in 1939.

Continental Plans—German plans to make Europe self-sufficient in the chemical field were revealed in the middle of 1941 by I.G. Farbenindustrie, which has just boosted its capitalization to 800 million RM in order to increase participation in foreign industries. Since France and England have been largely eliminated as competitors on the continent under wartime conditions, some of the "New Order" plans have already been put into effect. They call for complete continental reorganization of the chemical industry, with Reich interests taking over financial control in some instances, building new plants or expanding old ones in areas best suited by reason of location of raw materials or cheap power or labor. Plants requiring an abundance of electricity would be located in Scandinavian countries. For example, Norway could supply synthetic fertilizers and aluminum to France, Spain and the Balkans. In return, France could send bauxite needed for aluminum production to Norway. Yugoslavia, able to build an electrochemical industry on the basis of cheap power, labor, river transport, and possessing copper (German interests have recently acquired the formerly French-owned Bor mines), bauxite, chrome, antimony, lead, zinc, and timber as raw materials would become the center of the Balkan chemical industry, with Bulgaria and other southeastern European countries supplying additional raw materials.

Lineup in Greatest War in the World's History

(Prepared by the U. S. Census Bureau from latest figures available)

Countries	Population (Millions)	Area, Thousands of Sq. Mi.	Density per Sq. Mi.	Wheat, Percent	Potatoes, Percent	Sugar, Percent	Petroleum, Percent	Coal, Percent	Iron Ore Products, Percent
THE WORLD	2,133	52,231	40.9	100	100	100	100	100	100
PRINCIPAL ANTI-AXIS BELLIGERENTS									
United States (Including Possessions)	151	3,734	40	14	4	15	63	34	38
United Kingdom (Including Possessions)	501	13,354	37	13	4	22	2	24	10
U.S.S. Russia	170	8,167	21	27	26	9	10	9	15
China	412	3,784	109	10	..	..	..	..	..
Netherlands Indies	69	735	94	..	..	5	3	..	..
Thailand	15	200	75	..	..	..	..	..	..
Total	1,318	29,983	44	64	34	51	78	67	63
PRINCIPAL AXIS BELLIGERENTS									
Germany (including Austria)	76	214	356	3	23	8	..	14	3
Finland	4	148	25	..	1	..	..	..	..
Hungary (Trianon Territory)	9	36	252	1	1	..	..	..	..
Italy	45	120	378	5	1	1	..	..	1
Roumania	19	111	175	2	1	..	3	..	..
Japan (including Korea and Formosa)	102	247	411	1	1	4	..	4	..
Manchukuo	43	503	86	1	..	..	..	1	..
Bulgaria (including So. Dobrudga)	7	43	156	1	..	..	..	..	..
Albania	1	11	97	..	..	..	..	..	..
Total	306	1,433	214	14	28	13	3	19	4
PRINCIPAL AXIS OCCUPIED AREAS									
Belgium	8	12	700	..	1	1	..	2	..
Czechoslovakia (before Sept., '38)	15	54	281	1	5	2	..	1	1
Denmark	4	17	225	..	1	1	..	..	..
Estonia	1	19	59	..	..	..	..	..	..
France	42	213	197	4	6	3	..	3	12
Greece	7	50	142	..	..	..	..	..	..
Latvia	2	25	78	..	1	..	..	..	..
Lithuania (including Memel)	3	22	118	..	1	..	..	..	..
Netherlands	9	13	679	..	1	1	..	1	..
Norway	3	125	23	..	..	..	..	..	1
Poland	35	150	232	1	16	2	..	3	..
Yugoslavia	16	96	164	1	1	..	..	..	..
French Indo-China	24	286	82	..	..	..	..	..	..
Total	168	1,082	155	7	33	10	..	10	14
RESOURCES MORE LIKELY AVAILABLE TO ANTI-AXIS GROUP									
Balance of North America (except U. S. and Canada)	37	1,780	67	..	..	13	2	...	..
South America (except foreign controlled)	94	6,921	14	3	..	5	9	..	1
Egypt	17	386	43	1	..	1	..	..	..
Iran	15	634	24	1	..	..	4	..	..
Iraq	4	117	32	..	..	..	2	..	..
Total	167	9,838	17	5	..	19	17	..	1
RESOURCES MORE LIKELY AVAILABLE TO AXIS GROUP									
Spain	26	194	134	..	..	1	..	..	..
Sweden	6	173	37	..	1	1	..	..	9
Total	32	367	88	..	1	2	..	..	9

European and Asiatic Turkey has a population of 17,870,000; occupies 297,000 square miles; has a density of 60; produces 2 percent of the world's wheat. This tabulation does not attempt to compute the proportion of normal Russian resources now controlled by German occupation nor the proportion of Chinese resources controlled by Japan as a result of occupation. Production figures shown will not always total 100 percent because productions of less than one percent are not included.

In Rumania a specialized chemical branch would be built around the mineral oils (formerly Anglo-Dutch, American, and French-owned) and vegetable oils found there. After careful studies of the economic structure of southeastern Europe, I.G. Farben around 1935 started financing and supplying technical assistance to develop soya bean growing in Rumania. The proceeds from crops, purchased completely by Germany, were used for importing chemicals manufactured by I.G. In this way, while expanding the sale of chemicals, this firm also acquired foodstuffs and raw materials for the Reich, and I.G. economists have gone further and estimated that by raising per capita import purchasing power of the Balkans to one-half that of Germany, a billion mark gain of chemical exports to the Balkans would result, the bulk of which would presumably be supplied by the Reich.

In France, bauxite deposits would be developed further, and the existing well-rounded organic and inorganic industry would be expanded. France, it will be remembered, is the fourth largest chemical producer in the world. German financial penetration there was revealed with the announcement in December 1941 that I.G. Farben has obtained control of three leading French concerns, Kuhlmann, National Coloring Matters and Chemical Products Co., Ltd., of St. Denis, and French Chemical Products Co. of St. Clair du Rhone.

ITALIAN CHEMICAL PRODUCTION

Italy, although possessing a considerable electrochemical industry of her own which is rapidly being expanded, fits into the Axis picture as a supplier of certain manufactured chemicals to Danubian areas, but more as a source of raw materials, mercury, sulphur, pyrites, zinc, and bauxite. In the case of mercury Italy has become the world's largest producer (45 percent of the world total in 1937) when Spanish production was crippled during its year and a half of civil war. As the world's second largest producer of sulphur (10.7 percent of the world's total in 1937, 80 percent being U. S. produced), and fourth largest producer of pyrites (8.6 percent of world's total in 1937), Italy has a large surplus of raw materials for sulphuric acid.

Italy's chief sources of supply for

the chemical as well as other industries have become Germany and Yugoslavia, which has now been divided into the Kingdom of Croatia, ruled by the Italian Duke of Spoletto, Serbia, and in parts of Yugoslavia incorporated into the Reich by way of Austria, and those occupied by Bulgaria and Hungary. Former Yugoslavia had a surplus of cereals, meat, timber, copper, lead, chrome, and antimony, but the Reich is bidding against Italy for some of these items. In present wartime trade Germany is providing the southern axis partner with coal, steel, potash, and magnesite, and in return is receiving hemp and silk in addition to sulphur and mercury. Total trade between the two axis partners was reported in December 1941 to have tripled since 1939 and is supposed now to exceed 2,000 million RM.

The chemical industry has long been organized on a military basis by means of confederations and trade associations, with prices, exports, research, etc., all being government controlled. For both Italy and Germany the transition from a "Wehrwirtschaft" ("defense economy") to a "Kriegswirtschaft" ("war economy") was therefore easily accomplished. The same relative position occupied by I.G. Farben in Germany is held in Italy by Montecatini, Societa Generale per l'Industria Mineraria ed Agricola, Milan, largest chemical and mining concern of southern Europe, in which French, Swiss and German capital were still also represented as late as 1937. The present extent of foreign participation in this or any other chemical concern in Europe is not known, since such matters, along with production and operation figures that might be of military importance or of value to competitors, have always been carefully guarded secrets. Montecatini operates more than 200 plants either directly or as subsidiaries and affiliates, and accounts for the largest part of Italian chemical production. Its mining and metallurgical activities include numerous pyrite, sulphur, lead and zinc, lignite and bauxite mines.

Italy, with 9.6 percent of the world's total in 1937, follows France and Hungary as Europe's third largest bauxite producer. Montecatini produces roughly one-half of Italy's aluminum. Total Italian aluminum output was about 32,000 tons in 1939, 40,000 tons in 1940, and is predicted to reach 65,000 tons by 1942-3, with an eventual goal of 100,000 tons.

Magnesium production is comparatively recent, Italy's requirements having been imported until 1936. The Milan automotive and airplane Fraschini interests through the "SAMIS" organization started producing magnesium from dolomite in March 1940 and have two plants running and a third under construction in Bolzano, South Tyrol. Montecatini, which also erected a factory in Bolzano in 1938 is producing magnesium from the same raw material as well as by way of magnesium chloride from sea water. Total Italian magnesium production in 1942, however, will only be around 3,000 tons.

Thanks to synthetic production, the southern Axis partner is self-sufficient in nitrates, but deficient in potash and phosphates, phosphatic rock ordinarily being imported from the United States. Fertilizers are, of course, of great importance in Italy's drive to raise more farm products, especially wheat. Nitrogen fixation and synthetic nitric acid manufacture have expanded rapidly in recent years, although Italy is still behind Japan in total capacity. Domestic resources, such as coal, lignite, shale, and asphalt rock, have been utilized increasingly, chiefly by Montecatini, for making synthetic motor fuels. Production is still far behind the Reich. Rayon as well as staple fiber production, especially from casein, has also been expanded in the past few years. Production of essential oils, and organic and inorganic chemicals for export is well developed. Italy is the world's second largest producer of olive oil (24 percent of world's total in 1938-9), but is deficient in other vegetable oils.

JAPANESE CHEMICAL INDUSTRY

Japan's chemical development during the past ten years has been remarkable. Although still importing considerable chemicals, partly for military reasons, Japan in the past few years has also become an important exporter, especially in Eastern markets. The production value of Japanese chemicals and allied products was 851,000,000 yen ($238,800,000) in 1934. From 1935 to 1937 chemical output increased by more than 50 percent to a total of 1,424,594 yen ($400,000,000), of which industrial chemicals had a value of 506,950,000 yen; fertilizers 379,883,000; pharmaceuticals 123,574,000; soap, perfumery and toilet preparations, 109,631,000; and dyes and intermediates, 70,730,000 yen. Exports reached a peak of 188,300,000 yen ($48,000,000) in 1939, while imports dropped from a 1937 peak of 211,510,500 yen ($60,915,000) to 139,000,000 yen ($36,000,000) in 1939. The higher import figure was attributable partly to higher prices and partly to abnormal demands resulting from military activity. In 1938, 58 percent of Japan's chemical exports went to the yen-bloc Japanese-dominated areas of China, Kwantung Province, and Manchuria, while sharp declines were recorded to other countries such as the United States.

Japan's chemical industry, like that of the other Axis members is chiefly in the hands of a few large concerns as the Mitsui, Mitsubishi, Sumitomo, and electric enterprises. For price control and other official regulating functions the industry is divided into 22 major subdivisions, and in many cases is government subsidized, especially in undertakings outside of Japan proper or in unprofitable production.

Japan's chemical industry is based on its available raw materials, ordinary coal (not cokable), sulphur, pyrites, chrome, magnesite (in Manchukuo), and some copper and timber. In common with Axis partners it lacks cotton, wool, petroleum, and rubber. For fertilizers Japan has sufficient synthetic nitrate plants (over 8 percent of the world's installed capacity), but must import potash, phosphates, and soya bean cakes, partly from its mandated islands, and Korea and Manchukuo.

Japan is now self-sufficient in ammonium sulphate and some is even available for export in years when power shortages due to droughts do not occur as in 1934 and 1935 and 1939. Ammonium sulphate capacity in Japan proper, Chosen (Korea) and Manchukuo in 1935 was 1,625,800 tons, and has undoubtedly increased in the meantime. Superphosphate capacity is around 2 million tons, but raw materials have to be imported.

Since Japan has some copper it has not had the same incentive to developing aluminum as an alternate material as Germany and Italy. As a result of military needs, however, Japan has had to carry on extensive research to overcome the handicap of having no domestic bauxite resources.

Some aluminum companies are now taking up magnesium output along with the primary magnesium producers, some of whom use German patents. Japan's magnesium raw material basis is considerably better than for aluminum since adequate quantities of magnesite are available. At first sea water was used, but now magnesite from Manchuria and Korea is the principal raw material. Man-

(Please turn to page 95)

Petroleum's Past, Present and Future

ROBERT P. RUSSELL *Executive Vice President, Standard Oil Development Co.*

Chem. & Met. INTERPRETATION

At a dinner sponsored by the Junior Chemical Engineers of New York during the Chemical Exposition, the author gave this remarkably comprehensive review of the oil industry. It contrasts petroleum, from a tonnage basis, with some of the other industries so often regarded as outstanding examples of American mass production methods. Chemical engineers will be interested in seeing how favorably this great chemical process industry compares with those in which mechanical operations largely predominate. The answer is found in the former's dependence upon research and engineering development.—*Editors.*

In trying to make a guess as to the position which the petroleum industry may be in following the war it seems simplest first to take a look at the status of the industry today, then to take a brief backward glance and from these two vantage points attempt to take the look ahead.

The petroleum industry in the United States in 1941 will have refined about 1,400,000,000 bbl. of crude oil which is at the rate of about 200 million tons per year. About 44 percent by volume of the crude run to stills will wind up as gasoline, making the 1941 gasoline production approximately 90 million tons. This gasoline will be sold at about $16 per ton as it leaves the refinery. The steel industry, which is generally looked upon as the greatest of the "tonnage" industries in 1941 will make about 84 million tons of steel which will sell at the mill gates for approximately $38 per ton. It is interesting also to compare the petroleum tonnage figures with tonnages of other industries now very much in the limelight. For example, take aluminum which, if hopes are realized may, in 1942 produce 600,000 tons or about 1/150th of our gasoline tonnage.

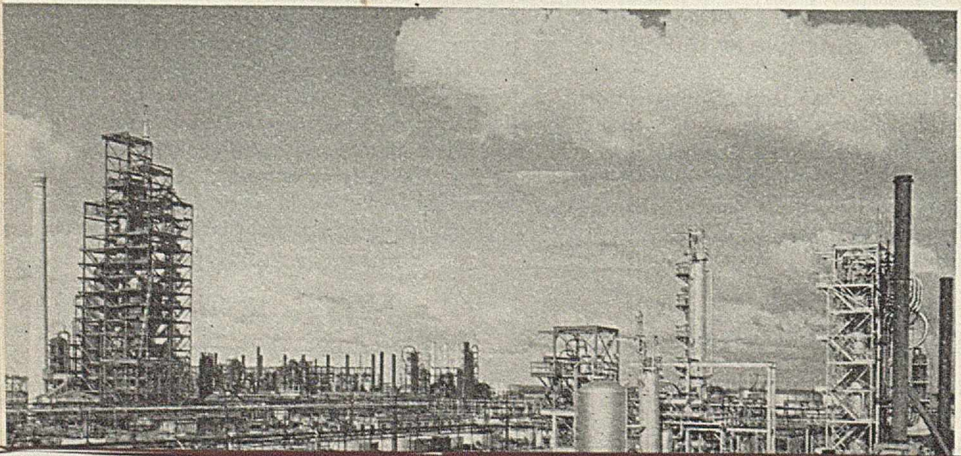
Consider the situation for 100-octane number gasoline: This material contains about 50 percent of a material which in itself is a synthetic organic chemical and which ten or fifteen years ago sold for nearly $10,000 per ton. It is estimated that almost 2,500,000 tons of 100 octane number gasoline will be produced during 1941 and will be sold at the refinery gates for about $50 per ton. If present expansion plans are completed, the industry will be producing at the rate of some 7,000,000 tons per year at the end of 1942.

These tonnage and price figures for petroleum production appear all the more remarkable when one considers that the oil must first be found, that expensive wells must be drilled to secure the crude oil, that this crude must be collected, sent through mammoth pipe line systems into terminals, and then transported by the enormous tanker fleet to the refineries where, finally, it must be refined in equipment of great technical complexity. All this has required capital investment by the industries of the United States of something in the order of $15,000,000,000 and the year-round efforts of some million people whose annual "take-home" is in excess of $1,500,000,000.

The technical complexity of the operations involved in the oil industry is indicated by the fact that the petroleum industry employs a little more than 10 percent of all the research and development workers in the United States. All of the chemical and allied industries together, which normally would be expected to require technical endeavor many times greater, employ less than twice as many people as the oil industry alone. Since 1927 the number of technical people employed in the research and development end of the oil industry has increased seven-fold. During this same period, the chemical and allied industries have increased only three-fold, the rubber industry has expanded to only twice its formal level and the electrical and communications industries have stayed almost constant. (See "Growth of Research" by George Perazich and Philip M. Field, *Chem. & Met.*, Sept. 1939, pp. 523-25.)

In addition to the technical complexity of the oil business itself, it must be realized that petroleum fractions provide the raw materials on

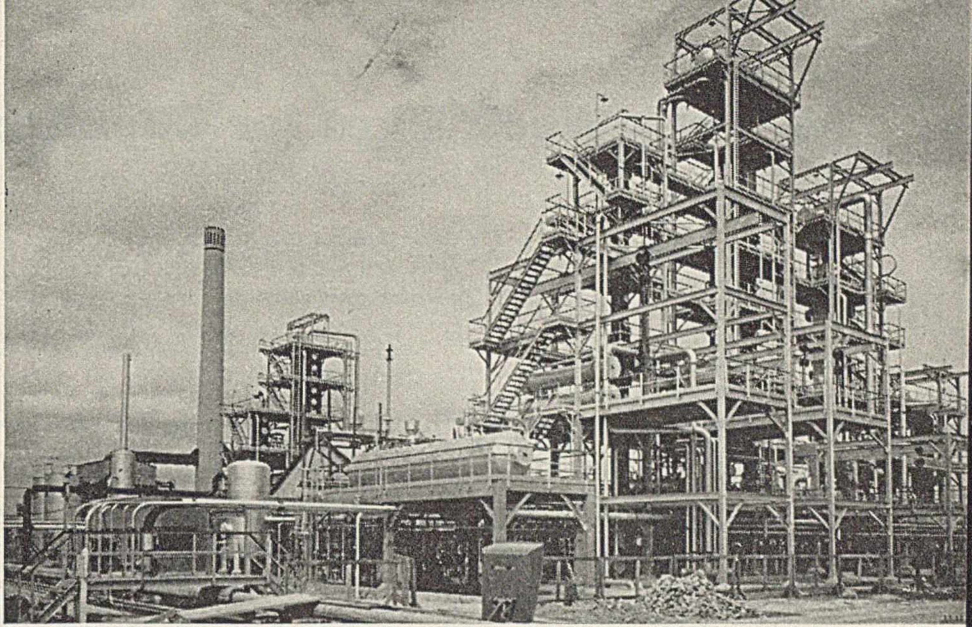
At the left, a new fluid catalyst cracking plant under construction. At the right, a polymerization unit for high-octane motor fuels



which a large chemical industry is based. Alcohols, glycols, ketones, aldehydes, organic acids, plastics, solvents, synthetic rubber, and numerous other products are produced in large volume even today. Under the stimulus of war requirements, this chemical industry is in the process of rapid and important expansion. Although accurate figures are not available, it is likely that the present gross volume of this particular chemical business is well in excess of $100,000,000 a year and it is conceivable that it will reach several times this volume in the course of the next two or three years.

In the refining of oil, rapid advances in the technology of chemical engineering have made it possible to produce increasingly greater yields of more valuable products, and at the same time effect substantial improvements in quality. Twenty years ago gasoline yields on crude were 26 percent, whereas today they are 45 percent. Over this period crude runs have increased four-fold and gasoline production has increased seven-fold. Quality has steadily improved to meet the requirements of high compression motors characterized by improved performance and economy. Accepting ASTM octane number as a measure of anti-knock quality, the average gasoline supplied to the American public in the last 16 years has increased from approximately 50 octane number to 73 octane number today, accompanied by increase in volatility to improve starting and acceleration. In regard to aviation fuels, the development of 100 octane gasolines has given an increase in power of approximately 20 percent over the 87 octane grades in commercial use at present, and an increase of 50 percent over the 70 octane gasolines in use 10 years ago.

Other products have been made available for new economic uses. The increase in distillate oil for household heating, with attendant cleanliness and economy, is evidenced by the fact that over two million oil burners are in use in American homes today. The consumption of heating oils has almost doubled in the last five years. Industry in general owes much to the development of economic, high quality lubricants, and marine shipping has been greatly advanced through the economic use of fuel oil. In the field of oil transportation, the widening use of crude oil pipelines and more recently the development of gasoline pipelines have facilitated the economic distribution of petroleum and its products, which distribution has been aided by increasing efficiency in the ocean transportation of oil by tankers.



Gas manufacturing plant in a large Eastern refinery which supplies the petroleum hydrocarbons used for industrial chemicals

That the benefit of improvement in technique and lowering of cost has been progressively passed on to the consumer is illustrated by the fact that in 1920 the average gasoline price in 50 major American cities was 29.74c. per gal., without taxes. In 1932 it was 13.3c. per gal. Today it is 14.04c. per gal. In the 21-year period the taxes have increased from 0.09c. a gal. to 5.95c. a gal. Thus, lowering the price has been sufficient over the period to absorb the whole tax increase, and pass along a net saving of approximately 10c per gal. to the motorist. In comparison with other commodities—taking 1923 as an index, present prices of gasoline have been reduced by 37 percent since that time. During this same period, the average price of essential commodities (food, clothing, housing, fuel, etc.) decreased by only 15 percent, or by substantially less than the reduction in the cost of gasoline to the public.

WHAT ABOUT THE FUTURE?

What is ahead for the industry and for the public which uses the industry's products? A large number of very large capacity processing units employing most modern catalytic technique are either already installed or will be installed immediately to meet the necessities of the defense program. Within the next two or three years it is expected that catalytic cracking units capable of treating something in the order of 500,000 bbl. per day, will be in operation. These units will be capable of converting about 50 percent of the material charged to the catalyst into 80 motor octane or 90–95 research octane gasoline. These 250,000 bbl. per day (30,000 tons per day) of extremely high octane number gasoline should be considered in the light of present requirements for premium grade motor gasoline which for 1941 was approximately 180,000 bbl. per day.

In addition to the catalytic cracking units there is tremendous expansion in such lines as hydroforming, alkylation, isomerization, and others. Thus after the war there will be available tremendous volumes of superior quality motor gasoline constituents which for a time at least would presumably be available for use in automobile engines since aviation gasoline requirements may drop sharply for some period at least following the cessation of hostilities. If these superior quality materials do go into motor gasolines, automobile engines designed to take full advantage of them could be improved to give economy 50 percent better than that now realized, or power output from 70 to 100 percent greater than is now obtained. After the war tremendous quantities of both aliphatic and aromatic chemicals can be made from the petroleum fractions which will be produced from the installed capacity of these new processes.

With the tremendous increase in utilization of the newer and more intricate catalytic operations, with the tremendous expansion in chemicals produced from petroleum, the petroleum industry which already has been a tremendous user of technical manpower, probably will be one of the major (if not the most important) users of the chemists, chemical engineers, physicists, graduated from our technical institutions.

A Work-Week Plan for Chemical Industry

ROBERT R. LYMAN *The Gray Chemical Co., Roulette, Pa.*

DONALD F. OTHMER *Polytechnic Institute of Brooklyn*

Chem. & Met. INTERPRETATION

With the labor situation becoming steadily more complicated by federal and state laws, and in view of Washington's call for doubled and quadrupled production of war materials the Gray system of scheduling continuous shift work is now worth special consideration. This progressive rotation system for four shifts on a 32-hour cycle and a 168-hour work week has stood the test of four years continuous use and comparison by actual operation with numerous other schemes. The authors state that none approach it in advantages—*Editors.*

A WORKING schedule for seven day, full-time operation of a factory which provides exactly the same conditions for all workers and gives each man five full days of 24 hours off every week has been in successful practice for over four years at the Gray Chemical Co., a well integrated, modern wood distillation plant manufacturing charcoal, refined acetic acid, various grades of methanol, activated carbon, and rough and finished lumber. The novel plan is really based on the substitution of new time units for the usual ones: instead of a 24-hour day, a 32-hour cycle (four 8 hour shifts); instead of a seven-day week, a four-day rotation; and instead of a calendar month, four weeks (28 days of seven rotations) which period acts as a common denominator of days, shifts, cycles and weeks.

168 WORK-WEEK

In operations requiring 168 hours of work per week, scheduling is usually done with four operators, one of whom must always be at the post. On equal division of time, each worker must spend one quarter or 42 hours per week. The problem is to allot time to treat fairly the four men and have the minimum disadvantages in changing schedules. Habits, outside activities, sleeping considerations, wage-hour laws and many other factors must be considered.

The Gray plan of progressive-rotation follows the simplest possible pattern. A man works eight hours, is off 24 hours and repeats indefinitely without change. Thus out of 32 hours, A is on eight, off 24 and tends the post one quarter of the time. B takes over at the end of A's shift and then is also always on eight hours and off 24. C follows B identically and D always follows C to complete the cycle. There are *never* any "shift changes"; every man's lot is always identical; and they all "progress" and "rotate" consecutively.

FEATURES OF GRAY PLAN

1. Every man always has at least 5 full days off every week.
2. No relief men are required.
3. Every man always has three out of four Sundays off for church, and three out of four of every other weekly recurring times.
4. No long shifts *on* or short periods off and no weekly change of shifts with accompanying disruption of sleeping habits, barely acquired from last change.
5. Every man may have *off* at least half of the day time everyday; and desirable sleeping time every night.
6. The simpliest possible pattern; no printed schedules necessary.
7. Overtime reduced to theoretical minimum and bookkeeping minimized.
8. Same men always working together every day.
9. Supervisors see every man at least once every four days.
10. No man ever works over 8 hours in any calendar day or consecutive 32 hours.

Since there are three shifts of eight hours per day and four of these in the four-man cycle, at the end of four days the rotation is complete and every man starts his shifts at the same hour as he did the first day; and each man has worked each of the three shifts. Unfortunately, however, the days of the calendar week are seven; and four-day rotations and seven-day weeks will not end together oftener than every 28 days.

THE PATTERN

The pattern is illustrated by the chart where the time *on* duty of each man is indicated by the corresponding letter (e.g. A is indicated in boldface). The other letters indicate that the other men are taking their turns and that A is *off* duty. It is assumed in this case that the week begins at 12 midnight Sunday morning. The eight-hour shifts run from 12 midnight to 8 a.m., from 8 a.m. to 4 p.m., and from 4 p.m. to 12 midnight. B follows the same schedule one day later; C, two days later, and D, three days later; or putting it differently, A follows the schedule that B worked the preceding week, that C worked two weeks previously, and that D worked three weeks previously. Regardless of starting time, every man has had the same treatment within four weeks, and will have the same pay. For companies using a four-week month or "13-period year" this is a considerable additional advantage if synchronized thereto. Furthermore, each man will always have three out of four weekly recurring hours off, such as church time, union meeting hour, night school class, etc. Because of the length of time off, it has been found simple in an emergency for one of the partners to work part or all of a man's shift if he must be absent, and this without working a hardship on the substitute.

A major advantage discovered is that the several men in a department in a larger plant, or the several departments of a small plant having

Sample Shift Schedule of Gray Plan

On — Off	1st. Week							2nd. Week							3rd. Week							4th. Week						
	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
Mdt.—8 AM....	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
8 AM—4 PM....	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C
4 PM—Mdt.....	C	D	A	B	C	D	A*	B	C	D	A	B	C	D*	A	B	C	D	A	B	C*	D	A	B	C	D	B*	A

The time of shift changes may be adjusted to best suit conditions.

* This shift represents the sixth or "overtime" shift in this particular arrangement which each man has one week in four. Other arrangements give two weeks without overtime and two weeks with overtime adjustable in any desired way so that sum is eight hours.

only one man per shift at each post, always have the same team of men operating at any one time; and this group of men working always together, build up a better spirit of cooperation than if the group is continually broken up by non-uniform shift changes. Of equal importance is the fact that the supervisor, working only during the day time, will see every man at least once in four days, while in schedules changing shifts weekly, it may be several weeks before a supervisor sees certain men.

FIVE SHIFTS PER WEEK

One important consideration is the requirement of the Wage-Hour Law that all time over 40 hours in any week is paid as overtime. Any schedule giving one man less than 40 hours increases the overtime to another, although eight hours overtime must be paid every week. No matter when *this* schedule starts every man will work at least five full shifts or 40 hours. In the diagram, A works six shifts or 48 hours the first week and thus receives all of the overtime, while each of his partners work only the regular 40 hours; but each receives, one week in four, the full eight hours overtime. There could be nothing simpler since a man either works five or six shifts weekly.

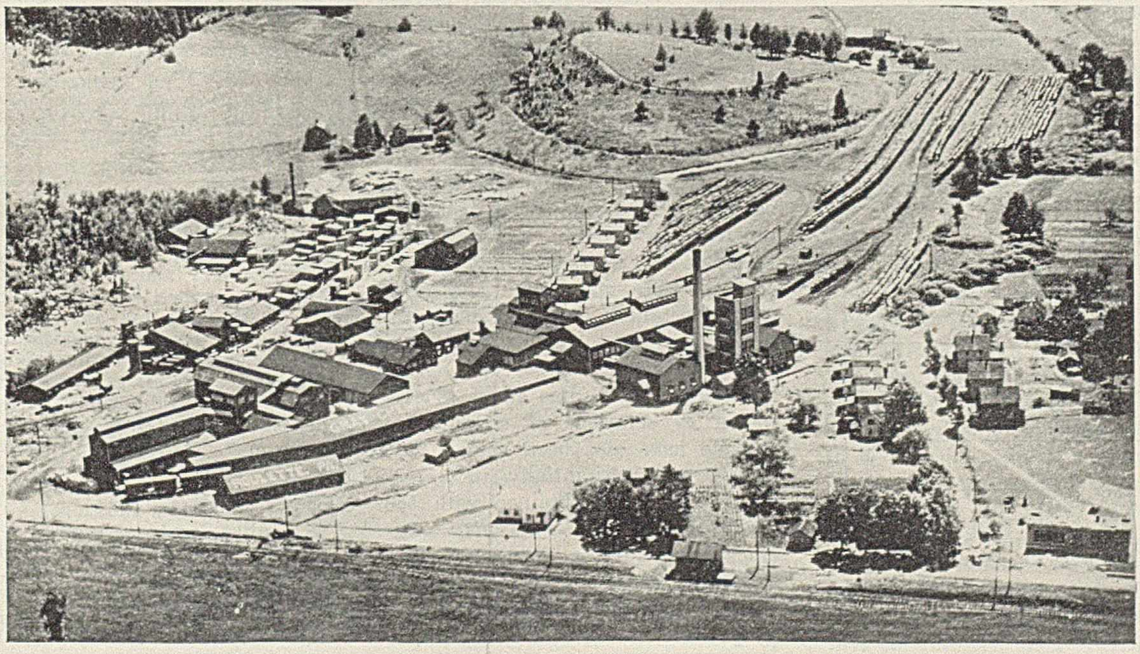
There are no variations of the uniform pattern; but the question *"When does it start"* is important. The diagram indicates the calendar week beginning and ending with a man coming to work and one leaving. If the plant week does not start at midnight Saturday night, or if the shifts do not start at midnight, 8 a.m. and 4 p.m., the program may be moved forward any desired number of hours to give different overtime arrangements, (always two weeks without overtime, and the other two weeks dividing eight hours, as 4-4, 5-3, 6-2, 7-1, or 8-0.)

Gray employees prefer to start at noon, 8 p.m., and 4 a.m., as this always gives them at least half of the daylight off every day (morning or afternoon), for their own pursuits; and divides up the night in such a way that it is easy to get to sleep. Furthermore, all shift workers can have their noon dinner at home at about the normal time. Also, the day-working supervisors contacts two sets of shift workers each day.

The plan was first used in the chemical plant, where one man handles his post without relief throughout his shift and eats his lunch without leaving and on company time. In some cases it is desirable that he stop his work to eat. By allowing 23 minutes off per shift for lunch, however, a man will average 40 hours a week. A longer lunch period may be worked out to minimize overtime, if the schedule is used wherein a man works five and one-half shifts for two consecutive weeks (or really 11 shifts within the two calendar weeks) and then two weeks of five shifts each. If the eight extra hours are divided into rest periods, there results 11 such periods of 43.64 minutes. Streamlining this to a 45 minute lunch period will give two work weeks of $39\frac{7}{8}$ hours each and two work weeks of $36\frac{1}{4}$ hours each, with no overtime to be paid. The simplest system, with one hour off for lunch, would reduce time to seven hours of pay for each trick; or $38\frac{1}{2}$ hours for each of two weeks, and 35 hours for the other two.

A *three* man combination working nine-hour shifts with one hour off for lunch and coming back in 18 hours, instead of 24, will work a 27-hour cycle, instead of 32, which returns to starting point in nine weeks. It averages a little less than 50 hours a week.

The work-week plan has been operating successfully for several years at the Roulette, Pa., plant of the Gray Chemical Co.



Aluminum-Magnesium Alloys

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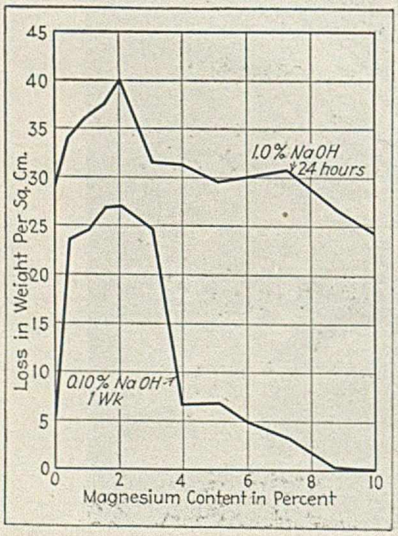
Chem. & Met. INTERPRETATION

In recent years many alloys have come into prominence for the construction of chemical engineering equipment, among them are the aluminum-base materials containing varying amounts of magnesium. In many cases they have marked resistance to the corrosion of alkalis. Recently, the authors have completed a series of tests which throw additional light on this resistance to chemicals.—*Editors.*

THE WIDESPREAD INCREASE in demand for aluminum in the past 50 years undoubtedly has been realized because of two main factors. The first was Hall's discovery of the electrolytic method for obtaining aluminum by the reduction of aluminum oxide, while the second was the exploitation of the alloying characteristics of the metal itself. The importance of the first discovery cannot be over-estimated since it shortly resulted in a reduction in cost of from $8 to $2 per lb.[1] and, together with other subsequent improvements in manufacture and greatly increased consumption, has resulted in a basic price of about $0.15 per lb. In connection with the second factor, it is of interest to note that more than 30 years ago a statement was made that "it is not improbable that the alloy producing capacity of aluminum may eventually prove its most valuable characteristic."[2] As a matter of fact, this characteristic has resulted in the production of alloys suitable for use in the chemical industry, in structural applications, as well as in the expanding aircraft industry.

Fig. 1—Effect of change in magnesium content on rates of attack of Al-Mg alloys in 0.1 and 1 percent caustic at 31 deg. C.



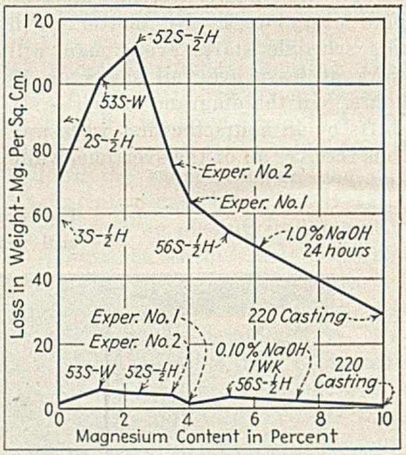
Among the alloys that have come into prominence during the past few years are aluminum-base alloys containing varying amounts of magnesium. These alloys not only possess the characteristics of lightness in weight inherent in both metals, but also exhibit in many cases marked resistance to the action of alkaline media.[5,8,11] The authors have shown in a recent publication[7] that small additions of magnesium to aluminum do not result in improved resistance to attack by sodium carbonate solutions but that alloys containing 4 percent or more magnesium are much more resistant to attack in such solutions.

More recently, comparisons of the resistance of the same alloys to corrosion by solutions of sodium hydroxide have also been made. The results are substantially in agreement with those obtained with the sodium carbonate solutions, inasmuch as alloys containing less than 3 percent magnesium showed less resistance than did certain aluminum alloys containing no magnesium, while alloys containing more than 4 percent magnesium exhibited improved resistance to corrosion. It was also found that alloys of aluminum containing more than 3 percent magnesium were less resistant to solutions of sulphuric acid than were those containing lesser amounts of magnesium. In other words, alloys of aluminum containing more than 3 percent magnesium appear to exhibit, in a measure, the corrosion characteristics of magnesium itself. In alkaline solutions where magnesium itself is resistant, they showed improved resistance, while in acid solutions where magnesium is readily attacked, they showed lowered resistance.

METHOD OF TEST

The investigation was conducted in a manner similar to that previously

Fig. 2—Effect of change in magnesium content on rates of attack of commercial and experimental alloys exposed in 0.1 and 1 percent caustic at 31 deg. C.



described.[7] Alloys containing 0.00, 0.46, 1.01, 1.54, 2.05, 3.08, 3.99, 5.17, 6.10, 7.25, 8.77, and 10.13 percent magnesium were used in tests made with 0.001, 0.010, 0.10, 1.00 and 10.0 percent solutions of sodium hydroxide and sulphuric acid. The aluminum base used in making these alloys was 99.984 percent pure, containing 0.004 percent silicon, 0.008 percent iron, and 0.004 percent copper, while sublimed magnesium containing 0.01 percent aluminum and 0.01 percent Group 2 metals was used for the magnesium additions.

The alloy ingots were given a homogenizing anneal, hot rolled to 0.64 cm., given an intermediate anneal, and then cold rolled to 0.064 cm. thickness. The sheet material then was stored at room temperature for six years before

Resist Attack

being used in this test. Duplicate specimens, 1.9 x 6.4 cm., of the alloys, were cut from the sheet and were degreased twice in carbon tetrachloride immediately before exposure to the action of the sodium hydroxide or sulphuric acid solutions. Tests were also made with a number of commercial and experimental wrought aluminum alloys.

C.p. sodium hydroxide and sulphuric acid (sp. gr. 1.84) and distilled water were employed in making the solutions used in this investigation. In order to prevent possible contamination, the solutions were not exposed to laboratory air for any extended period of time prior to use in the test.

The test was conducted by partially immersing the specimens in 100 cc. volumes of the media contained in Pyrex glass beakers which were kept in desiccators in an air chamber maintained at 31 deg. ± 1 deg. C. A stream of purified air (maintained at 25 cc. per min.) was drawn through the desiccators during the time the test was under way. This air was purified by "washing" with 10 percent (by weight) sulphuric acid and 10 percent sodium hydroxide solutions. Each desiccator contained a small amount of distilled water to prevent evaporation of the test solutions.

The specimens were weighed before exposure and after certain preselected intervals, and the tests were terminated with the different solutions as follows: 0.01 percent sulphuric acid after one week; 0.1, 1.0, and 10.0 percent sulphuric acid solutions after 24 hr.; 0.001, 0.01, and 0.1 percent sodium hydroxide solutions after one week; 1.0 percent sodium hydroxide after 24 hr.; and 10.0 percent sodium hydroxide after 2 hr.

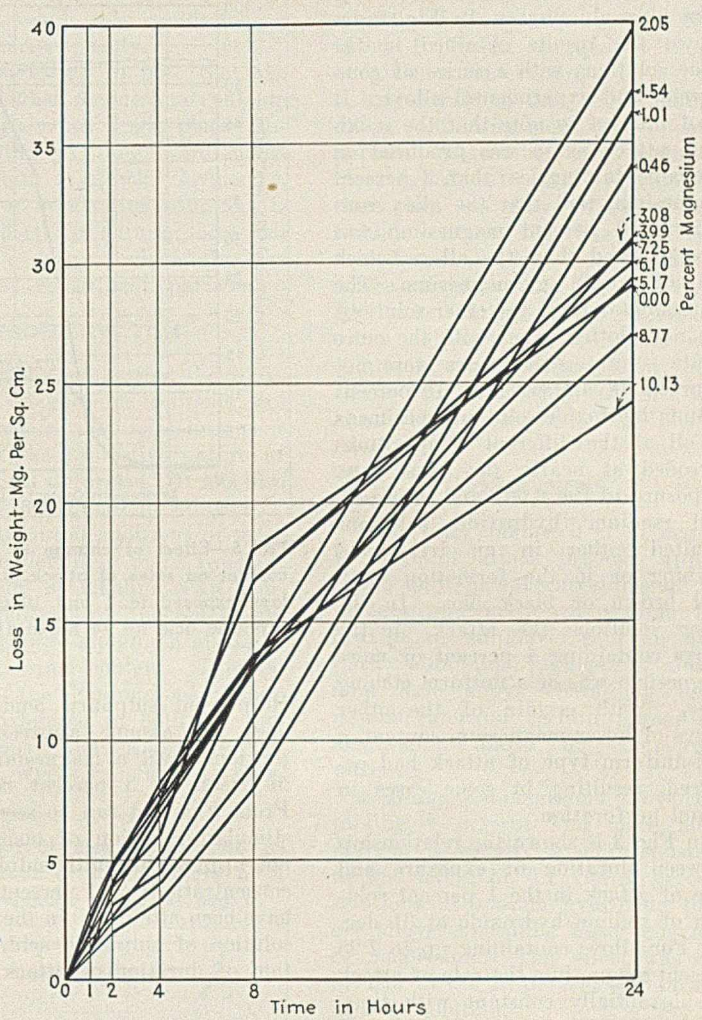


Fig. 3—Effect of time of exposure on rates of attack of Al-Mg alloys by 1 percent caustic at 31 deg. C.

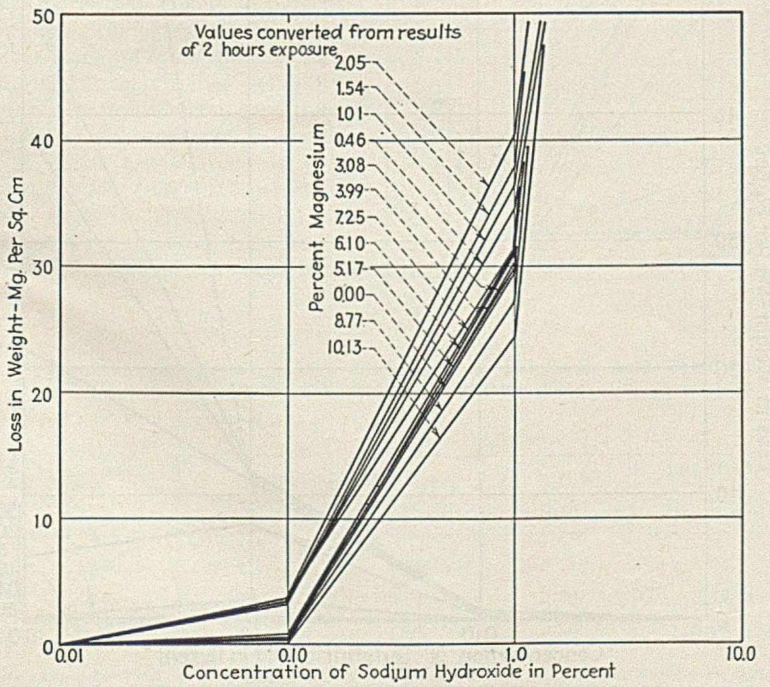


Fig. 4—Rates of attack on Al-Mg alloy specimens exposed for 24 hr. in caustic at 31 deg. C.

RESULTS

The results of tests with the sodium hydroxide solutions are shown in Fig. 1, 2, 3, and 4. Fig. 1 shows that the amount of attack with a group of special alloys in 0.1 percent sodium hydroxide for one week, and in 1 percent sodium hydroxide for 24 hr., is appreciably higher with alloys containing between 0.49 and 3.08 percent magnesium than with alloys containing greater amounts of magnesium, or even with aluminum containing no magnesium; while alloys containing 9 or 10 percent magnesium are definitely less attacked than pure aluminum. In Fig. 2 are shown the results obtained in the same solutions with a series of commercial and experimental alloys. It is of interest to note that the maximum attack again was produced on alloys containing less than 4 percent magnesium, and that the alloy containing 10 percent magnesium was less attacked than the alloys which did not contain any magnesium. The results obtained in the other solutions are not plotted, since with the more dilute solutions the losses were not appreciable, and with the 10 percent sodium hydroxide solution, specimens of all of the different compositions corroded at nearly the same rate. Exposure in the 0.001 and 0.01 percent sodium hydroxide solutions resulted either in an irridescent staining or in the formation of a dull brown or black film. In the other solutions the attack on the alloys containing 4 percent or more magnesium was of a uniform etching type. With certain of the other alloys of lower magnesium content, a non-uniform type of attack had occurred, resulting in some cases in actual perforation.

In Fig. 3 is shown the relationship between duration of exposure and rate of attack in the 1 percent solution of sodium hydroxide at 31 deg. C. For alloys containing up to 7.25 percent magnesium the rate of attack is substantially constant with time, but for the alloys containing 8.8 and 10 percent magnesium it appears that the rate of attack falls off with increasing duration of exposure.

The effect of increased concentration is clearly shown in Fig. 4. No appreciable weight losses were obtained in the 0.001 and 0.01 percent solutions. With the 0.1, 1, and 10 percent solutions a very marked acceleration of attack resulted.

SULPHURIC ACID

In the exposure to sulphuric acid solutions, the results varied characteristically from those obtained with the sodium carbonate and sodium hydroxide solutions. The decreased resistance to the acidic media with increasing amounts of magnesium is clearly shown in Fig. 5, 6, and 7. Fig. 5 shows that the attack in 1 or

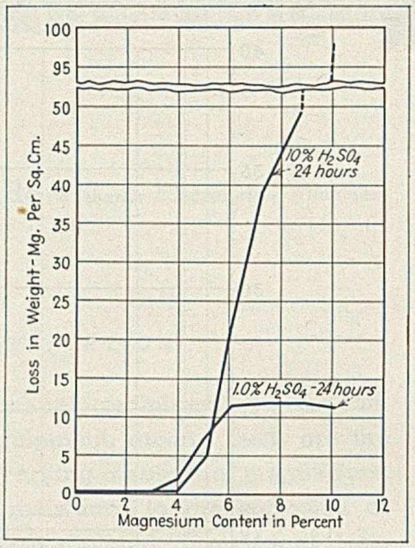


Fig. 5—Effect of change in magnesium content on rates of attack of Al-Mg alloys exposed in 1 and 10 percent sulphuric acid for 24 hr. at 31 deg. C.

10 percent sulphuric acid solutions does not assume appreciable proportions until a magnesium content in excess of 3 percent is reached. From Fig. 6 it can be seen that the stimulating action of magnesium is not appreciable until sulphuric acid concentrations of 1 percent or above have been attained. In the 1 percent solution of sulphuric acid, the relation of duration of attack and rate of attack is shown in Fig. 7. Here again it can be seen that only when the magnesium content becomes greater than 3 percent does the attack of the sulphuric acid solution become appreciable. The 0.001 and 0.01 percent solutions produced only a non-uniform staining on all specimens, while in the 0.1, 1, and 10 percent solutions, the attack was of a uniform etching type.

SULPHURIC ACID INHIBITED

Another test was made with three of the commercial and experimental alloys to determine their behavior in solutions of sulphuric acid "inhibited" with sodium dichromate. Since sulphuric acid solutions are commonly used for dissolving flux residues from welded aluminum articles, some contamination by chlorides (from the flux residues) naturally is encountered. Consequently, this test also included sulphuric acid solutions containing a definite amount of chlorides (as sodium chloride) with and without an addition of sodium dichromate. The results are given in Table I and show:

1. With increasing magnesium content a decrease in corrosion resistance resulted, which was in agreement with the results previously discussed.

2. The addition of chlorides as sodium chloride had no appreciable effect upon the corrosiveness of the

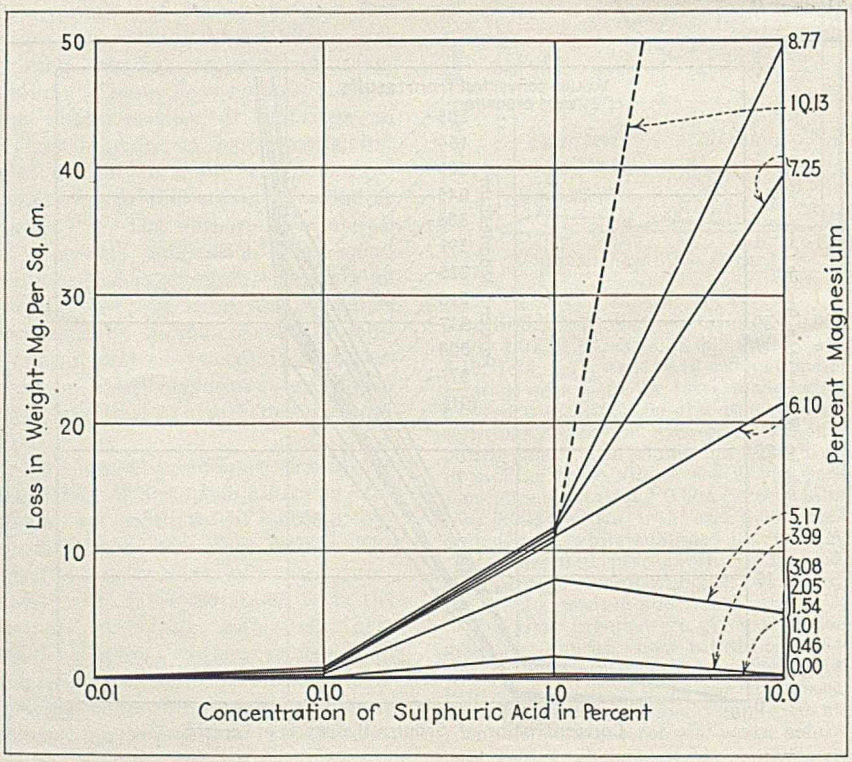


Fig. 6—Rates of attack on Al-Mg alloys exposed 24 hr. in sulphuric acid at 31 deg. C. 10.13 Mg alloy entirely dissolved in 10 percent acid in 24 hr.

sulphuric acid solution, as measured by weight changes.

3. The addition of sodium dichromate served as an "accelerator" of attack rather than an inhibitor. When added to the sulphuric acid solution, the attack was tripled; while with the sulphuric acid and sodium chloride solution the attack was between 25 and 30 times as great.

The stimulating action of dichromate additions is in agreement with results obtained by Evans with chromic-sulphuric acid solutions on iron[3], as well as with those obtained by other investigators.[6,10] The attack on the aluminum in the sulphuric acid, the sulphuric acid and sodium dichromate, and the sulphuric acid plus sodium chloride solutions was of a uniform etching type. However, in the sulphuric acid-sodium chloride-sodium dichromate solution, the attack was largely of a severe, non-uniformly distributed pitting type. Similar severe pitting sometimes results when insufficient additions of inhibitor are made to chloride solutions to which iron, steel, zinc, and aluminum specimens are exposed.[9]

DISCUSSION

The reason for the rather abrupt change in the rates of solution of aluminum alloys containing less than 3 or 4 percent magnesium as compared with rates for alloys of higher magnesium contents is not definitely known. Microscopic examinations of the specimens indicated that particles of the aluminum-magnesium constituent were present in those alloys containing more than about 2 percent magnesium. The change in behavior, therefore, does not quite coincide with the apparent magnesium solubility limit. Under equilibrium conditions the solubility of magnesium in aluminum at room temperature is evidently rather low (under 0.5 percent)[4] so that finely divided particles of the aluminum-magnesium constituent may have been present in alloys containing even less than 2 percent magnesium, although this could not be verified microscopically.

It is interesting to note that the alloys of higher magnesium contents were definitely not single phase materials, although they were much more resistant to attack. Evidently, if corrosion in alkaline solutions is electrochemical in nature, local cell action was not stimulated by the presence of constituent particles.

PROTECTIVE FILM

Probably the reason that the alloys of higher magnesium contents are less attacked in alkaline solutions is because of the protective nature of the film which is formed. It has also been noted that aluminum alloys containing substantial additions of magnesium are definitely more resistant to the action of alkaline soap solutions or solutions of ammonium hydroxide than are aluminum alloys of lower magnesium content. This superiority of the aluminum-magnesium alloys is exhibited in both hot and cold solutions. Thus, it appears that, in general, where resistance to alkaline environments is desired the aluminum alloys containing more than about 4 percent magnesium should be given consideration.

In contrast to this, the aluminum alloys containing more than about 3 percent magnesium are definitely more rapidly attacked by acid solutions than are alloys of lower magnesium content. This has been confirmed under actual service conditions where alloys such as No. 43 or No. 406 have withstood the action of dilute sulphuric or hot citric acid solutions much better than have alloys B214 (3.8% Mg, 1.8% Si, balance Al) or 214 (3.8% Mg, balance Al).

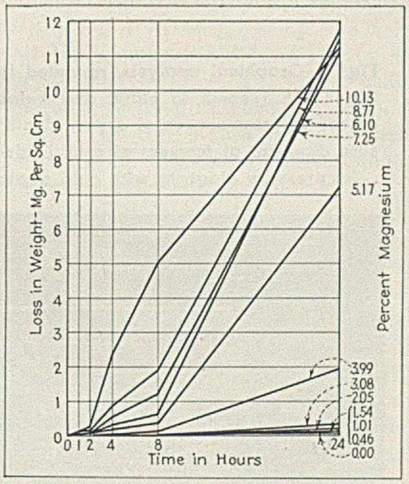


Fig. 7—Effect of time of exposure on rates of attack of Al-Mg alloys by 1 percent sulphuric acid at 31 deg. C.

CONCLUSIONS

1. In tests conducted at 31 deg. C the rate of attack becomes appreciable only in concentrations of 0.1 percent and above of sodium hydroxide or sulphuric acid on high purity aluminum, high purity aluminum base alloys containing magnesium, and on certain aluminum-magnesium alloys of commercial purity.

2. Aluminum-magesium alloys containing 4 percent and more magnesium are equally or more resistant to the action of 0.1 and 1 percent solutions of sodium hydroxide than are alloys containing lesser amounts of magnesium. This effect was not evident in the 10 percent sodium hydroxide solution.

3. Alloys containing 4 percent and more magnesium are less resistant to the action of 0.1, 1, and 10 percent sulphuric acid solutions than are alloys having lower magnesium contents.

4. An addition of sodium dichromate to a 10 percent sulphuric acid solution accelerated the attack somewhat, while a similar addition to a sulphuric acid-sodium chloride solution served to produce a very material acceleration of attack.

Table I—Effect of addition of Sodium Dichromate to Sulphuric Acid Solutions in Contact with 2S, 52S, and 56S Aluminum Alloys

Alloy	Nominal magnesium content, %	Loss, mg./sq.cm.			
		10% H_2SO_4	10% H_2SO_4 +1.0% $Na_2Cr_2O_7$	10% H_2SO_4 +10 g/1 NaCl	10% H_2SO_4 +10 g/1 NaCl + 1.0% $Na_2Cr_2O_7$
2S	0.0	0.21	0.69	0.24	6.94
52S	2.5	0.33	0.78	0.36	8.12
56S	5.2	0.75	1.98	0.76	8.68

Specimens exposed for 24 hr. at room temperature. Values given above are averages from 3 specimens, 0.16 cm. x 2.5 cm. x 10.0 cm. These specimens were immersed to a depth of about 5.0 cm.

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How Friction and Forced Draft Affect Stratification in Kilns and Dryers

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***Chem. & Met.* INTERPRETATION**

This article and one which preceded it (*Chem. & Met.*, Oct. 1941, pp. 83–85) are the result of an extensive study which the author conducted for the purpose of determining the best means of improving heat distribution in convection-heated kilns and dryers. The earlier article studied the stratification of gases in such equipment under the simplifying assumption of frictionless gas flow in an empty, natural-draft tunnel drier. This article shows effects on stratification of gas friction, of loading and of forced draft, as well as the combination of natural and forced draft, and draws a number of conclusions regarding the means for eliminating or minimizing stratification and the bad effects that follow from such a condition.—*Editors.*

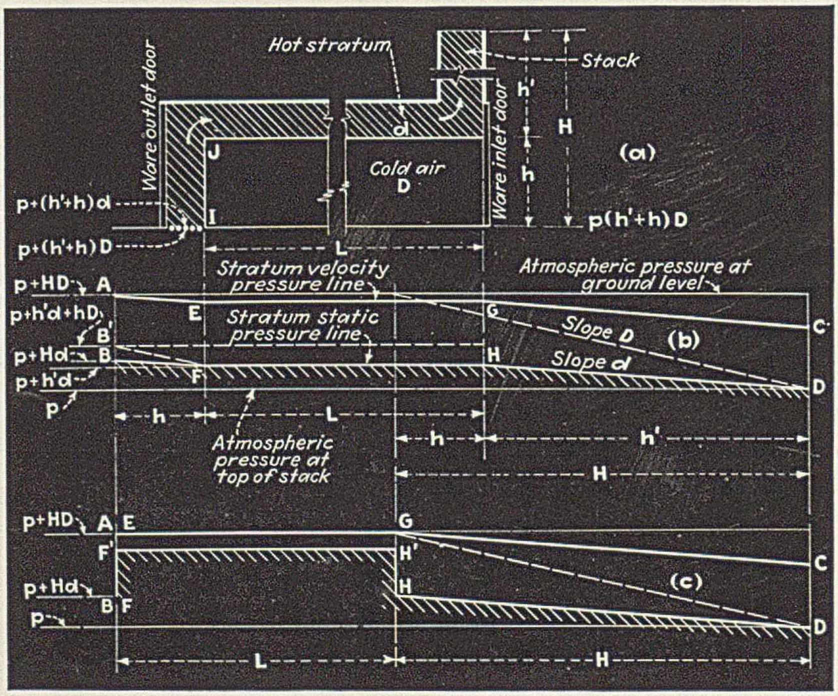
Successful operation of such widely diversified types of equipment as chemical product furnaces, tunnel and periodic dryers, kilns, metallurgical furnaces and recuperators, depends upon uniformity of temperature or the controlled distribution of heat to the material undergoing treatment. This applies with equal force to all sorts of equipment in which heat is transferred by convection. In such equipment stratification of the heating gases often occurs and upsets the design calculations. It was, therefore, the author's purpose in carrying out the study which resulted in this, and an earlier article (*Chem. & Met.*, Oct. 1941, pp. 83-85), to examine both causes and means of preventing stratification and the ways whereby performance of the equipment could be improved.

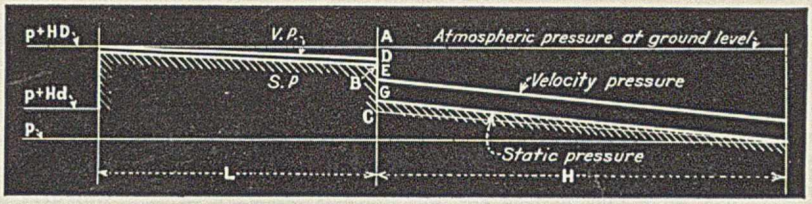
In the earlier article the situation was studied under the simplest conditions, assuming no friction of the gases, an empty dryer, and natural draft operation only. The present article removes these restrictions and examines the effects of friction, of loading, and of the use of forced draft, either alone or as a supplement to natural draft.

Initial operation of a natural draft dryer finds it filled with cold air which during operation is eliminated, all or in part, as more and more hot air is passed through it. Fig. 1*a* shows the cross section of the dryer studied in the earlier article. The hot air is of density d, and the cold air of density D. Atmospheric pressure at the top of the stack is taken as p, the overall height of the stack as H, the height of the cold stratum in the dryer as h, and the distance from the stack top to the bottom of the hot stratum as h'. Hence, atmospheric pressure at the ground outside the dryer and under the heating coils is $p + (h' + h)D$ or, since $H = h' + h$, it may be written $p + HD$. Similarly, inside the dryer above the coils, the pressure is $p + (h' + h)d = p + Hd$.

Frictionless flow is of course purely theoretical and in practice the total pressure difference at the dryer inlet must not only create the outlet velocity but also overcome the friction resulting from the flow so that the same pressure difference will supply a smaller draft than that theoretically possible. This is expressed by $(p + HD) - (p + Hd) = dv^2/2g + F$ in which the velocity v is smaller than the value of V given in the first article. The quantity F is that part of the total pressure difference available which is not transformed into velocity pressure because it is required to overcome friction. It shows up in the

Fig. 1—Graphical analysis, repeated from the author's first article, showing conditions with respect to static and velocity pressures in a theoretical (frictionless) dryer: (a) cross section of dryer, identifying various points and elevations; (b) pressure diagram at moment of establishing natural draft under frictionless conditions; (c) pressure diagram with cold stratum eliminated under frictionless conditions





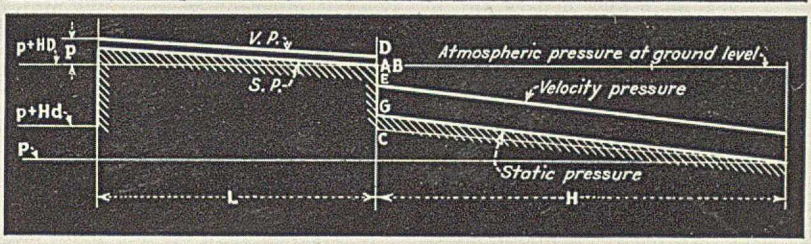


Fig. 2—Pressure diagram showing effect of friction in a natural draft dryer, assuming a constant gas density and no stratification

Fig. 6—Pressure diagram in a combination forced and natural draft dryer, with the total pressure difference increased to the limit

form of additional static pressure in the hot stream. This additional pressure difference decreases as the air travels, of course, since it is used up in overcoming friction due to motion. It is equal to zero at the outlet of the system (top of the stack) because the total friction which has been overcome at that point is F. The friction is a function of the velocity and it is customary to consider its variation as being proportional to the square of the velocity, expressing it as $F = k'v^2$ or $F = kdv^2/2g$. In the latter formula, which features the velocity head, k is the coefficient of resistance of the system. It would be a constant if the square law held for all velocities. Such is not the case, however, and for low velocities the variation is proportional to a smaller power of v, the value of which varies with the system and the velocity.

In any event, on account of friction, the static pressure of the hot stratum at any given point on the separation plane between it and the cold air is increased by the quantity f, which is the friction remaining to be overcome between the point considered and the stack outlet. This extra pressure f of the hot stream is communicated to the cold air below, so that at ground level the static pressure of the latter is $p + h'd + hD + f$. Now, equilibrium requires that the static pressure of the cold air remain constant down the dryer. Since f decreases down the dryer, the hot air stratum must contract. If we call A the internal height of the dryer; x the stratum depth and f the friction remaining to be overcome; and x_0 and f_0 the same quantities immediately to the right of point J (Fig. 1*a*), we have $p + xd + f + (A - x)D = p + x_0d + f_0 + (A - x_0)D$. This expression, which after changing signs reduces to $x = x_0 - (f_0 - f)/(D - d)$, shows that the cold air pressure remains constant and also that the decrease in stratum depth, which is proportional to the friction, would be linear for a constant friction loss per foot travelled. The constant ground level pressure of the cold air is $p + h'd + hD + f_0$.

Since F is the total friction of the system, the suction at point I (Fig. 1*a*) will be caused by the difference $(p + h'd + hD + f_0) - (p + h'd + hd + F)$, or $(p + h'd + hD) - (p + h'd + hd) - (F - f_0)$. This is compared with the difference of $(p + h'd + hD) - (p + h'd + hd)$ which would hold in the case of frictionless flow. In other words, friction will in this respect retard the evacuation of the cold air. However, the difference $F - f_0$ is very small and this effect is negligible.

On the other hand, the pressure of the inside cold air is higher than in the case of no friction by the quantity f_0, so the difference with respect to the outside is reduced by the same amount and the inrush of cold air from the outside will be less.

Moreover, the friction encountered in the system is composed of two distinct factors—the friction against the walls and ceiling of the dryer and that against the cold air. Since the walls and ceiling are immovable, the first item is just a plain loss. In the second case, however, the cold air is free to move under the force of reaction set up against the friction and this circumstance gives rise to entrainment of cold air at the stratum limit, favoring the evacuation of the cold air in the dryer. Since the velocity in the hot stratum and therefore the friction decreases as the layer depth increases, it will be seen that the entrainment effect becomes less and less important as the stratum expands.

On the whole, friction will diminish stratification both by reduction of the leakage and by increase of the evacuation.

It will be noted that in the case of natural draft alone, the inside static pressure will always be lower than the outside, since its maximum value is given by $p + Hd + F = p + HD - dv^2/2g$. In other words, with natural draft alone, air will always enter through any possible leaks and every time the doors are opened. This will be seen on Fig. 2 which shows graphically the static and velocity pressure variations for a constant density and no stratification. The slope in the dryer is equal to its coefficient of resistance, while GC is the total resistance of the stack. In the case considered, the velocity pressure in the dryer is a quarter of that in the stack. The drop DE is the friction loss at entrance of the stack, assumed equal to one velocity head ($k = 1$).

It will be noticed, by the way, that the smaller the velocity increase when the air enters the stack, the greater will be the velocity in the dryer; hence the advantage of a large stack, although exaggeration in this respect will render difficult the establishment of the operating draft upon starting.

EFFECT OF WARE

When material to be processed is put into the dryer, it will obstruct the flow of the stratum and, like the baffling mentioned in the first article, will cause a backing-up in front of the ware to an extent determined by the fact that, for all practical purposes, the flow area remains the same through the ware as through the empty dryer. In other words, the back-up ratio will be equal to that of the free areas of flow with and without the ware. This is illustrated in Fig. 3 and expressed by $H/h = S/s$, in which H is the stratum depth before and in the ware, h is the depth when the dryer is empty (depth assumed behind the ware), s is the free area of flow when the dryer is loaded and S is the free area when empty.

The above formula brings out the great importance of reducing s as much as possible by close setting of the ware and reducing to a minimum the free space between the load and the walls and ceiling.

The baffling effect of the ware will cause considerable turbulence in the flow through partial transformation of velocity pressure into static pressure as the air strikes the ware. The result of this turbulence at the lower limit of the stratum will be a certain amount of mixing with cold air which will to some extent favor diffusion.

DENSITY VARIATION

Previously, we have considered the density of the stratum as remaining constant throughout. In practice, of course, there is a considerable density increase as the air travels on account of heat loss through the walls and ceiling, but principally through heat exchange with, and evaporation from, the ware. The result is a contraction of the hot layer. However, the stratum is limited on three sides by the ceiling and walls of the dryer so that the contraction will occur half vertically (decrease in depth) and half horizontally (decrease in velocity). The weight flow being constant, the velocity and depth at any point are therefore inversely proportional to the square root of the density at that point, as expressed by: $v/v_0 = H/H_0 = (d_0/d)^{1/2}$, in which H_0 and v_0 are the depth and velocity at the point where the density is d_0 (i.e., conditions at the inlet to the ware, for instance). For example, if before the ware the depth is 48 in. and the air is dry at 210 deg. F. (density = 0.059), a temperature drop down to 110 deg. and a humidification to 50 percent relative humidity (density = 0.068) will reduce the depth to $48(5.9/6.8)^{1/2} = 44.5$ in.

This contraction caused by density variation is cumulative with that caused by friction.

CONSEQUENCES OF STRATIFICATION

It is well known that the temperature and humidity variations of the air and ware in a dryer are controlled by the flow of air per pound of ware present in the dryer, and the rate of output of the ware. Supposing now that only half the ware is in the stratum, then only half of it will be treated and the output per pound present in the stratum will be the same as in the design calculations which assume that the air fills the dryer completely. However, the amount of air in the stratum will be that provided in the calculations for the entire load in the dryer so that the quantity per pound of ware present in the stratum will be double. Furthermore, the velocity of the air will be twice that intended and the coefficients of transfer greatly increased. The result will be much more rapid drying in the upper part of the dryer than called for by the design and the ware in this part will be overdried, while the temperature drop of the air will be increased. Hence, the contraction of the stratum on account of density variation will be greater than would be expected from the design figures.

In a properly designed dryer, the air outlet conditions are determined so that the dew point will be lower than the temperature of the ware as it enters the dryer (usually atmospheric temperature). The purpose of this point of design, of course, is to avoid condensation which reduces considerably both the drying capacity and efficiency of the process, while it may also be harmful to the ware.

Now, in the case where stratification occurs, the outlet temperature of the air will be lower than desired and the air may reach saturation with formation of fog. Furthermore, even if saturation is not reached, the fact that evaporation from the ware is greater than called for in the design is likely to raise the dew point above the temperature of the ware and cause condensation. The extent to which fog and condensation will occur depends upon the dew point margin adopted in the design and the degree of stratification.

The foregoing discussion brings out the fact that stratification will not only leave part of the ware untreated but also will cause wasteful and inefficient processing of the treated part since it will be unnecessarily overdried, while fog and condensation are made probable.

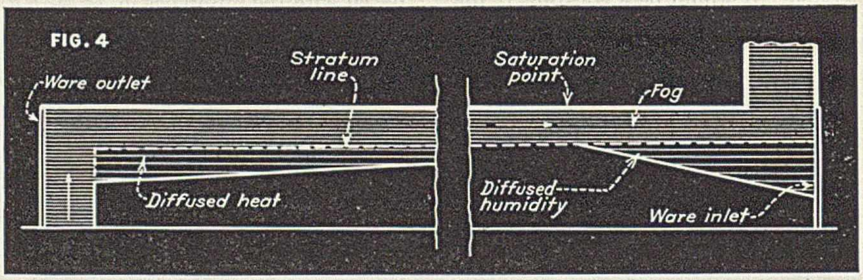
STRATIFICATION OF HUMIDITY

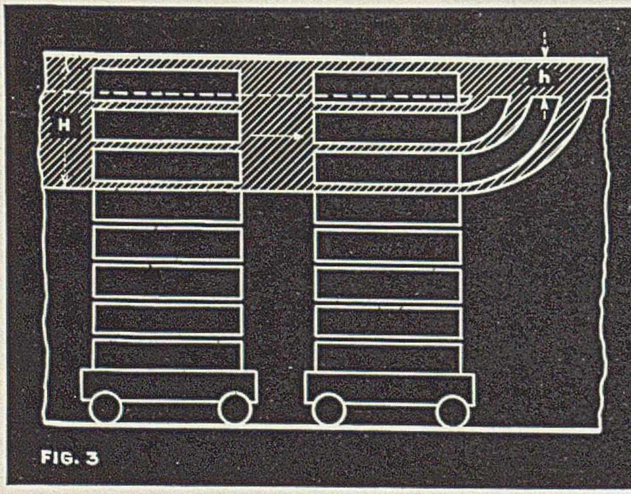
Disregarding diffusion, the humidity picked up by the stratum will remain in it for the same reason that hot air stratifies, that is, because it is lighter than the cold air below. Diffusion will occur, however, and

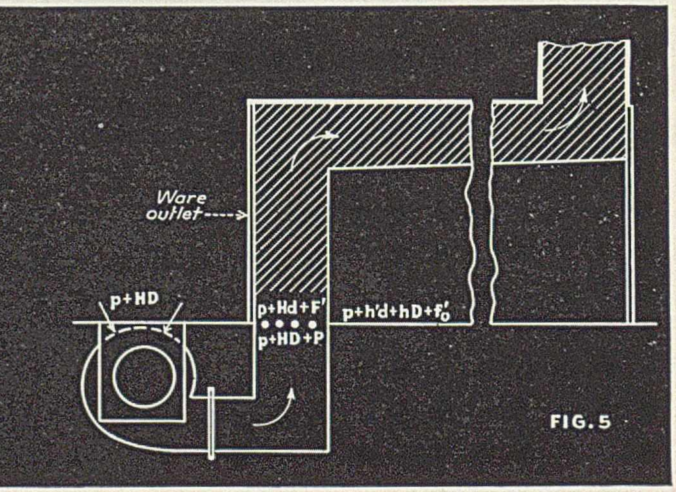
Fig. 3—Effect of ware in dryer on backing-up of hot stratum

Fig. 4—How heat and humidity diffuse in a tunnel dryer

Fig. 5—Pressure differences in a dryer using forced plus natural draft







instead of an abrupt change in humidity at the stratum limit, the variation will be more or less gradual according to the rapidity of the counterflows. In any case, since the rate of diffusion increases with the vapor pressure, the depth of the humid stratum will increase down the dryer because of the gradual increase in vapor pressure in that direction. If fog forms, either on account of stratification or because of faulty design, the cloud will collect against the ceiling and increase in depth.

Since the temperature of the stratum decreases down the dryer, it will be noted that diffusion of heat will be more pronounced at the hot end. The effect of diffusion of heat and humidity is shown in Fig. 4.

FORCED DRAFT

When air circulation through the dryer is due to natural draft only, the drying process is very slow because the available velocity head at inlet is limited by the heating temperature. Furthermore a higher pressure cannot be maintained inside than out, a necessary condition to suppress the inrush of cold air through leaks.

The combination natural and forced draft system is shown on Fig. 5; P is the total pressure created by the fan. The pressure at fan intake is atmospheric pressure, i.e., $p + HD$, so that the total pressure under the heater is $p + HD + P$ and the available velocity head is $(p + HD + P) - (p + Hd + F') = dv'^2/2\,g$. The pressure at ground level of the cold air in the dryer is $p + h'd + hD + f'_5$.

Since P controls the velocity head, the flow can be set at will by proper selection of the fan. It must be kept in mind however, that the resistance of the dryer and stack increase at the same time as the velocity head so that the static pressure increases. If the resistance is assumed to vary as the square of the velocity, the available velocity head will vary in direct proportion to the total pressure difference, which is expressed by

$$\frac{(p + HD + P) - (p + Hd + F')}{(p + HD) - (p + Hd + F)} = \frac{dv'^2/2g}{dv^2/2g} = \frac{v'^2}{v^2}$$

Owing to the simultaneous increase in static pressure, there is a limit to the desirable increase in P and as the latter increases, the usefulness of the stack and natural draft decreases. The limit is reached when the static pressure at the entrance to the stack has reached atmospheric pressure, i.e., $p + HD$. Then the stack becomes useless as far as draft is concerned. If the fan pressure is raised above the limit, the stack becomes not only useless but actually detrimental since, without it, the pressure P could supply more flow.

This is illustrated on Fig. 6 in which the total pressure difference of the system shown on Fig. 2 has been raised to the limit of desirability, that is to the extent where B has risen to point A (Fig. 2). The ratio of the limiting available total pressure difference to that with natural draft is equal to AC/BC, (Fig. 2) the value of which is 1.37 in this particular case. It will be seen on Fig. 6 that, with or without stack, the flow would be the same. It will also be observed that, the larger the cross section of the stack, the lower will be point B and the higher will be the limit for P.

In a rationally designed combination forced and natural draft dryer, the ware inlet end will therefore always be below atmospheric pressure to an extent which depends upon the proportion of forced draft used. Consequently, air will leak in under the door at the ware inlet end but not at the outlet. When the ware inlet door is opened, air will rush in until atmospheric pressure is reached and the dryer will therefore operate on forced draft alone. Since the operating pressure of the fan will have increased, less air will be delivered. Conversely, when the ware outlet door is opened, hot air will rush out.

The foregoing discussion shows that stratification, which is caused by the continuous or periodic admission of cold air, can be avoided by use of forced draft alone. When both forced and natural draft are used, stratification can be limited through close setting of the ware, airtight door construction and a loading schedule designed to reduce the number of openings to a minimum. The provision of inlet and outlet locks will of course reduce the amount of cold air admitted, although such a scheme to some extent complicates operation.

OUR ENEMIES

(Continued from page 83)

chukuo follows the U.S.S.R. and Austria as the world's largest magnesite producer, with 13.5 percent of world output in 1936. Production of magnesium started in 1931 in Japan, and is now believed to be around 3,000 to 4,000 tons with an ultimate goal of 17,000 tons a year.

Japan has also been using the Fischer-Tropsch synthetic fuel process. Nipponese long-range plans called for a production of 2 million tons of synthetic fuel in 1941, but probably only one-fourth this amount was actually realized. At the beginning of 1941 there were 21 plants either building or in operation, including 12 in Japan proper, 2 in Sakhalin, 2 in Korea, and 5 in Manchuria. Japan is also an important producer of synthetic fibers, rayon and staple, as well as of plastics, of which 90 percent of the Japanese output is represented by phenolic resins. Japanese dye production is relatively recent, and utilizes many German patents. Output increased by 30 percent in 1939 as compared with 1938, no figures being released for 1940. Quality is often reported to be unsatisfactory for Japanese dyestuffs as well as synthetic fibers.

There has been considerable collaboration of the three Axis powers in the chemical field, at least to the extent that German patents have been made available to them. All three have in common the fact that they have developed their chemical production during the past ten years strictly under government control with a view to military and economic self-sufficiency. This has meant coordinated research and the development of a variety of substitute or alternate materials, some of which will probably be dropped at the end of the war and some of which will undoubtedly be kept and developed further in all countries.

In military production it is significant that aluminum and magnesium output for aircraft and precision instruments was vigorously pushed at an early date by the totalitarian governments in spite of high production costs, thereby giving the Axis certain advantages here. In view of the importance of nitrogen in explosives manufacture, it is also obvious why the Axis powers have built up a synthetic ammonia plant capacity twice that of the rest of the world combined.

SUMMARY

While the above-mentioned factors seem to favor the Axis, the tremendous preponderance of natural raw materials available to non-Axis powers, the United States, and Great Britain as an Empire, and the Soviet Union, if properly developed and applied during a long run war, should more than counterbalance the initial advantages of the Axis powers.

Equipment in the Limelight—II

EDITORIAL STAFF REPORT

Chem. & Met. INTERPRETATION

This article, which is a continuation of one which appeared in our December number, completes our report of new developments which were found by *Chem. & Met.* editors at the Chemical Show in December. In our November issue a 21-page article dealt with developments in new equipment and construction materials for process plants which had been introduced in the two year period since the last Chemical Exposition. Information was secured from the Show exhibitors, as well as many non-exhibitors. However, many other developments were uncovered at the Show, and it is these that the present report seeks to cover.—*Editors.*

Continued from pages 83 to 86 of our December number, this article completes our report on new equipment and construction materials for chemical and process plants exhibited at the Chemical Show in December. The types of equipment covered in the earlier report included those for drying, heating and cooling; dust collecting; filtering; grinding and disintegrating; controlling, regulating and weighing.

Materials of Construction—Among the new developments of American Hard Rubber Co., was an improved hard rubber pail featuring a specially reinforced bottom to avoid distortion after continued use. Another innovation was an improved rotating seal for use on hard rubber centrifugal pumps in place of the conventional stuffing box and packing. A hard rubber sleeve on the shaft, sealed to the shaft by a soft rubber sleeve which also acts as a spring, is forced into liquid-tight engagement with a composition disk supported in the pump casing.

Another improvement shown by American Hard Rubber Co. was a new method of rubber-lining iron pipe to avoid producing a flow-disturbing bump at the end of the pipe. The pipe, after attachment of the flange, is chamfered so that the rubber lining can be brought out of the pipe and turned over the chamfer. The entire face of the flange is then rubber-covered to avoid bending stresses in the flange.

New industrial glassware shown by the Corning Glass Works, in addition to the new forms of Vycor 96 percent silica glass and the new small Corning-Nash Pyrex glass centrifugal pump described in our November Preview, included a glass float for use in unit humidifiers for operating the water control valve, and for other float-valve applications. Another showing was of a recently developed Pyrex glass plug-type valve employing a hollow glass plug to insure easy operation in plant applications.

An important point regarding the present situation in ply-metals employing stainless steel was brought out by the Jessop Steel Co. It was pointed out that the OPM allocation on stainless steel affects only those alloys containing 3 percent or more of chromium. A 20 percent plymetal using 18-8 stainless steel thus contains less than 3 percent of chrome and at present is not subject to allocation.

A new method of constructing chemical stoneware-lined tanks, employing this company's synthetic plastic sheeting, Pyroflex, was shown by Maurice A. Knight. Called Pyroflex Fused-on Tile construction, the new method of lining first coats the inner surface of the steel tank with Pyroflex, then applies the lining tiles to the thermoplastic Pyroflex by heating the Pyroflex with a blow torch and pressing the tiles against the fused surface. After the tile has been placed, the joints are pointed with any suitable corrosion-resisting cement. It is claimed that tile cannot fall out even if the joints let go. Another new development with this company is Pyroflex-impregnated glass fabric which is used for gaskets, for certain lining applications and for drip shields.

Indicative of the trend toward the development of new non-metallic materials of construction was a line of tubing fittings made from Seran, Lucite and Tenite, for use with Dow's Seran tubing, and at present available from Parker Appliance Co. in sizes from ⅛ to ⅜ in. The new fittings employ the Parker standard type of flared joint. This company also exhibited a new high-speed flaring machine for flaring the ends of ferrous and non-ferrous tubing for making up joints on a production basis.

Materials Handling, Power Transmission, Welding—Economy Engineering Co. exhibited an improved platform elevator equipped with extremely shallow base bars and rollers to allow the platform to come close to the floor. In this design the platform comes within 2¼ in. of the floor in the lowest position, compared with a standard height of 6 in. for a machine with 5-in. base wheels. Thus drums and barrels may be readily rolled onto the platform without using a ramp or skid.

Developed in Switzerland and available on the Continent for a number of years, the line of Castolin Eutectic low-temperature welding rods is now being produced in the United States by Eutectic Welding Alloys, Inc. These alloys are designed to operate at temperatures below the melting point of the parent metal. Alloys are available for use with cast iron, nickel, Monel metal, all types of steel including stainless, aluminum, bronze and copper alloys, magnesium and its alloys, and other metals. It is claimed to be possible to make welds which will not initiate electrolytic action; which will match the parent metal in color; which have high tensile strength; decrease warping; and require less preheating.

The Falstrom Co. showed its new barrel lift, a simple device for handling barrels or drums of any size. A two-wheeled truck with mechanism for attaching to the barrel is rolled up to the barrel as it stands on end. The barrel is then locked to the lift, elevated slightly by tipping the handle back, and moved to its new position.

A simplified type of package elevator was shown by the Lamson Corp. This elevator is readily portable and is adjustable to any operating angle from horizontal to a tilt of 30 deg. It employs a 14-in. continuous belt without belt side guards so that overhanging loads can be handled. Operating at a speed of 70 f.p.m., it requires ¼ hp. and can handle loads to 100 lb.

Further evidence of the spread of plastic compositions in industrial applications is the new ABK resinoid wheel now being employed by Rapids Standard Co. for industrial truck applications where a wheel is needed that is both easy on the floor, and proof against organic and dilute mineral acids as well as oils, greases and temperatures to 200 deg. F. In these wheels the tread is formed of canvas-laminated plastic while the web and hub, molded simultaneously, is of plastic reinforced with mascerated canvas.

In addition to new developments in its Redler conveyors, described in our Chemical Show Preview, Stephens-Adamson Mfg. Co. showed several improved members of its line of Sealmaster ball bearings. One new type is a cartridge unit for standard and medium duty, another a non-self-aligning type, permanently sealed and pre-lubricated, with an extended inner ring. A pre-lubricated self-aligning type designed for use as a hangar bearing for screw conveyors was also introduced, and a non-self-aligning type for use on conveyor carrier rolls, return and gravity rolls. New take-up bearings for conveyor head pulleys, mounted in frames for screw adjustment, were also shown.

Several new materials handling developments were exhibited by the Philadelphia Division of Yale & Towne Mfg. Co. Among these was the Midget King electric hoist, available in capacities from ⅛ to 1 ton. This hoist is light in weight and portable, and is equipped with anti-friction bearings throughout, a motor brake, a load brake, safety limit switch and other features available in larger hoists. A new hydraulic hand-lift truck for heavy loads, a midget fork truck, and an improved hand truck were also exhibited.

Mixing—An improvement now standard on its colloid mills was shown by Chemicolloid Laboratories. This is an air cooled thrust bearing which has been moved close to the motor and as far away as possible from the mill head. The new design is claimed to be particularly suitable for high temperature applications.

Kent Machine Works exhibited its latest type of motor-driven liquid mixer of the change can type, designed for handling batches up to 135 gal. This large unit has a structural steel column supporting the mixer proper, which can be elevated for clearing the top of the batch can. The mixer arm is counter-balanced. The 3-hp. motor is bolted near the base to keep the center of gravity of the mixer as low as possible.

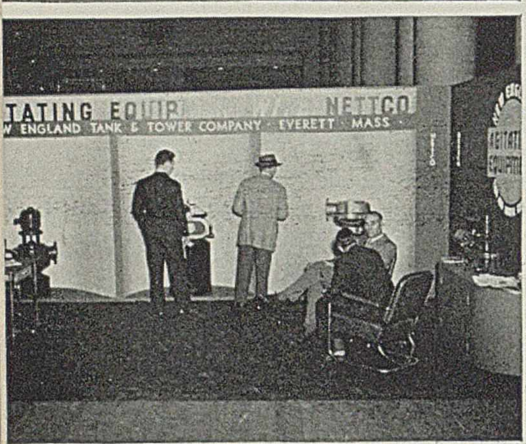
For use in all kinds of mixing operations where continuous single-pass treatment is not essential, the Premier Mill Corp. has developed a portable mixer available in three sizes, the working principle of which is identical with that of this company's colloid mills. The new mixer is claimed to do more than simple mixing or agitating because all particles in the mixer pass several times through the clearance between the rotor and the stator and are broken down almost to the extent possible with a colloid mill. This company also showed a new 2-in. rotor laboratory colloid mill with 1½ hp. universal motor specially designed for operation at 13,500 r.p.m.

The Asbury fluid impact mill for dispersion and homogenizing applications, described in our May 1940 issue, was shown by the Milton Roy Pump Co. which has now taken over distribution of this mill in the smaller sizes up to a rotor diameter of 9 in. Larger mills, with rotors 12 in. in diameter and above, are now being distributed by Patterson Foundry & Machine Co. This mill employs a horizontal disk rotating at high speed with feed at the center. Material is thrown outward, impacting against suitably arranged ridges or teeth on both the disk and the stator. Discharge is at the periphery. Close clearances are not required in this mill.

Packaging—A new idea for the handling of glass carboy jugs was shown by Carrier-Stephens Co., chemical manufacturers. The new device, which was developed by the company for its own use, is now on the market for the handling of glass containers both of carboy size and of 5-gal. size. It consists of a wire "bird-cage" supporting the bottle in a flexible manner. The weight is said to be 40 lb. less than a regulation carboy box. The device is known as the Steel-X carrier and has been designed for easy stacking of the filled carboys.

A completely automatic capping machine for the application of various types and sizes of screw and pressure caps to containers was shown by Elgin Mfg. Co. The only attention during operation required by this machine is filling of the cap-supply hopper. The caps are automatically sorted and fed. Variable speed is available for handling from 18 to 52 caps per minute, with instant adjustment possible for applying closures varying as much as 30 mm. in diameter. This requires but one setting, without changes to the hopper or chute.

Horix Mfg. Co. showed its new Model HBV18 automatic rotary filling machine for the filling of containers with liquids at speeds up to 125-150 pt. per minute. All parts coming in contact with the liquid are of stainless steel. A variable speed drive pulley permits synchronizing the machine with adjacent equipment. No labor is required except for changing from one size container to another. Safety devices automatically stop the machine in case a defective container comes into position or if a jam occurs in the



conveyor leading either to or from the filler.

Piping, Packing, Valves—Darling Valve & Mfg. Co. has introduced a new line of double-disk parallel-seat gate valves in a variety of materials especially for use in the chemical industry. These valves, known as the Specialloy line, may be produced in any castable alloy. They incorporate a unique revolving disk feature, with the disks free to revolve throughout their entire travel. A simple arrangement of disks and wedges avoids possibility of incorrect assembly or placing in the valve.

An improvement in its line of stainless plug valves was exhibited by the Duriron Co. Formerly, Durimet-body plug valves were fabricated using this alloy for both the body and the plug. It has been found that the combination of a Duriron plug with a Durimet body produces a non-sticking valve which ordinarily does not need lubrication. For special applications a lubricating fitting is readily attached and also a device for loosening stuck plugs.

Among developments introduced since the last Exposition, and shown by the Garlock Packing Co., was the company's new Lattice Braid packing. Every braiding strand passes diagonally through the body, giving a unified structure, braided internally as well as externally. Greater strength, better flexibility, controlled porosity and semi-automatic adjustment to the stuffing box are advantages claimed. Another new product shown was this company's Flange-Jacks, a simple tool for prying apart pipe flanges for the replacement of gaskets without danger to the flanges.

Hills-McCanna Co. exhibited several new versions of the Hills-McCanna Saunders diaphragm valve. One was a motorized valve of Saunders construction, made by Barber-Colman Co. Another was a carbon-body valve made of National Carbon Co.'s Carbate impervious carbon. In the past, standard construction of the Hills-McCanna Saunders valve has been to use a non-rising stem. The valve is now available in a rising-stem type to facilitate judging the degree of opening. Still another version of the valve substitutes a quick-opening handle for the hand-wheel. This operates a steep-angle cam which actuates the diaphragm, permitting opening and closing in 180 deg. of movement of the handle.

An interesting new rotating pressure joint, described as the Packless swing-joint multiple seal, was shown by Packless Metal Products Co. The seal, which can be designed for pressures in the range from full vacuum to 5,000 lb. per sq.in., is formed by a metal cylinder through which the fluid passes, within which is a conical expander loaded by a spring. Several such seals are employed in series. The design intends that only the first seal shall hold the pressure, while succeeding seals are held in reserve. The metal cylinders seal against a graphite-containing composition which is said never to require lubrication.

Pumps—A number of design changes have been incorporated in the Huber pump which, since the last Chemical Exposition, has been taken over by Downingtown Mfg. Co. This pump is now known as the Squeegee type. The pumping element consists of a rubber or synthetic rubber tube held within a casing and progressively compressed from the feed to the discharge point by means of an eccentrically rocked compressor ring. In the improved version the tube is formed exactly to the curvature of the casing. The rocker ring, which was previously free to rotate (although unlikely to do so), is now anchored against rotation by a swinging arm.

Hills-McCanna Co. showed its newly designed Type R proportioning pump for low delivery at high pressure. This low-cost construction employs a walking beam to actuate the two pumping cylinders. The motor oscillates the walking beam which then reciprocates the pistons through a stroke dependent on the adjustment of movable stops on the pistons themselves.

A pneumatically actuated diaphragm pump for the handling of abrasive or corrosive slurries was exhibited for the first time by Oliver United Filters, Inc. Either compressed air or vacuum applied to one side of a floating diaphragm in electrically timed impulses transmits its energy through the diaphragm to the slurry or solution being handled on the other side. All parts coming in contact with the material pumped are protected by rubber or neoprene. Ball-type valves are used to prevent possibility of clogging.

A recent development shown by F. J. Stokes Machine Co. was a solvent stripper designed for use as an auxiliary for its oil-sealed vacuum pumps for certain types of application. This unit employs steam distillation to remove low-boiling solvents and other volatile compounds from the pump sealing oil in cases where the oil contamination cannot be removed by the clarifier customarily supplied.

Among several types of proportioning pump exhibited by Wallace & Tiernan Co., the most recently developed variety was a belt-driven feeder for use where neither water pressure nor electric power is available. It can be operated from any available drive shaft, adjustments being accomplished by means of a hand crank which may be changed while the feeder is in operation. The pump employs a balanced diaphragm, a small valve and hollow shaft being used to trap water at the line pressure behind the diaphragm so that pressure on both sides is equalized to avoid strain.

An interesting type of proportioning pump employing a hydraulically compressed flexible tube as the pump cylinder was exhibited by Wilson Chemical Feeders, Inc., under the name of "Pulsafeeder." A piston designed for accurately regulatable stroke operates in a cylinder, applying pressure through a liquid medium to the walls of a flexible pulsating tube made of rubber, synthetic rubber or other materials. A feature of the design is that the pulsating tube operates under balanced pressure and hence requires no reinforcement.

Reaction and Absorption—An interesting idea for the absorption of gases in liquids was shown in the booth of Air & Refrigeration Corp. In conjunction with one of this company's capillary air washers for air conditioning, a glass-fiber-packed capillary washer cell was exhibited, having all metal parts covered by anode-deposited rubber. This particular cell was developed for washing air containing small quantities of HCl gas. Owing to the low resistance and high active surface obtainable with such cells, the method would appear to have application in other gas absorption applications.

Several new models of its tantalum hydrochloric acid absorption systems have been developed by Fansteel Metallurgical Corp. These are all intended for producing strong acid from gas containing HCl. Type AK is designed for a dilute gas containing a minimum of 50 percent HCl. Type ARN requires a minimum of 60 percent HCl in the feed gases. Type AL is intended for an 80 percent HCl gas. All of these types have somewhat similar design features. Gas first enters a secondary absorption column, consisting of a water-cooled tantalum tube which receives hot acid of comparatively low strength from the main absorption tower, cools it, and boosts the concentration to the value desired. The gas then enters a packed tower in which most of the absorption takes place. The tower is surmounted by a tantalum condenser which removes part of the heat of absorption and condenses vapors out of the vented gases.

Known as the Reactivator, a new water conditioning system has been introduced by Graver Tank & Mfg. Co. This system purifies water by an improved process of coagulation with upward sludge filtration. Foreign materials, both suspended and in solution, are percipitated and then utilized in successive treatment zones of a single tank. This method of upward filtration is said to remove even the smallest particles and to speed up purification greatly.

One of the features displayed by Metal Glass Products Co. was a new 25-gal. still designed for construction in Monel metal or stainless alloys. The still is jacketed for 60-lb. steam and designed for operation under 26 to 28 in. vacuum. The assembly includes the still body, a packed column, and a condenser and receiver. The condenser is particularly adapted to easy cleaning of the tubes. Tubes, tube sheets and shell are assembled by welding into a single unit. The heads, of a suitable cast metal, are then bolted on to the tube sheet with a simple gasket joint.

Safety and Fire Protection—An improvement in carbon dioxide fire extinguishers first developed by Walter Kidde & Co. for use on its 2-lb. extinguishers has now been adapted to its 4-lb. extinguishers. This is a trigger-type release valve control. Prior to the change in the 4-lb. unit, control was by means of a hand-wheel, making it necessary to use one hand for the valve and the other hand for the nozzle. The new design permits one-hand operation.

In addition to several improved designs of respirators for dust and metal fumes, the Willson Products Co. showed a new two-hour, all-purpose gas mask featuring a molded soft-rubber face piece and an improved timer showing the elapsed time the mask had been used since attaching a new canister. The mask is intended for protection against all industrial gas hazards.

Separation—Several design improvements were evident in the Bar-Nun sifter shown by B. F. Gump Co. This sifter is of the type employing a horizontal screening surface gyrating in a circle. The design has been simplified through substitution of a V-belt drive for the gear drive formerly used. The sifter box is now carried on vertical rods supported at either end on ball-bearing universal joints which are permanently lubricated. In the older design, the joints operated in a bath of oil and presented a sealing problem.

Allis-Chalmers Mfg. Co. exhibited an improvement in its low-head, heavy-duty sifters which is now standard in this class of equipment. Made in sizes from 10 to 60 sq. ft. of cloth, the improved sifters now permit easy removal of the sieves from the side, by the loosening of four bolts and a tension rod.

Two new developments were shown by Richmond Mfg. Co. One of these is a production-type laboratory sifter, said to give sifting results directly comparable with those of large-sized machines. The area of each screen is exactly 1 sq.ft. The system may be arranged for conducting either continuous flow or time-limit laboratory sifting tests.

Several installations have already been made of the Johnson electrostatic separator which was in development at the time of the last Chemical Exposition. This machine, produced by Ritter Products Corp., is available for large-scale applications in tonnages as high as 25 to 300 tons per hour. It is now being applied in such fields as the treatment of phosphate rock flotation concentrates. The new process is based on the discovery that it is possible to reverse the polarity of the electrostatic charge on many common economic minerals, thereby facilitating separation. To meet various requirements the company is now prepared to supply seven types of electrostatic separators, with three different types of electrical equipment.

The most recent development among the equipment manufactured by Sutton, Steele & Steele, Inc., and shown by Separations Engineering Co., is called the "Air-Float Stoner." Designed for the removal of stones, glass, bits of metal and other foreign materials from grains, soybeans and similar farm products, the new stoner makes the separation on the basis of the difference between the density of the stock and its contaminations. Material flows downhill across a rapidly oscillating deck, being rendered fluid by a diffused air-stream from a blower passing up through the deck. Stones sink immediately, work uphill and pass out of a throat at the higher end. The clean stock leaves the lower end of the deck.

A new application for its mixing machinery was shown by Turbo Mixer Corp. in the form of a new style subaeration flotation machine. The machine employs the company's standard gas-absorber unit which is said to be suitable for use in flotation cells from 1 to 10 ft. in dameter, without the use of an auxiliary air supply for aeration. Larger sized units can be produced if necessary by supplying air under pressure to the gas absorber unit.

CHEM & MET

PLANT NOTEBOOK

Timesaving Ideas for Engineers

NEW CHART SOLVES HEAT TRANSFER CALCULATIONS FOR FLUIDS IN VISCOUS FLOW REGION

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A METHOD of correlating heat transfer data in the viscous flow region, which is of special significance in the petroleum industry where transfer in this region is commonly experienced, is presented here. When fluid flows through a pipe in viscous flow, its viscosity at the heat transfer surface varies widely from the average viscosity. Sieder and Tate (*Ind. Eng. Chem.*, **28**, 1936, p. 1429) introduced a corrective factor which takes into account the viscosity gradient by means of the ratio μ_a/μ_w, that is, the ratio of average viscosity of the main fluid stream to its viscosity at the temperature of the tube wall.

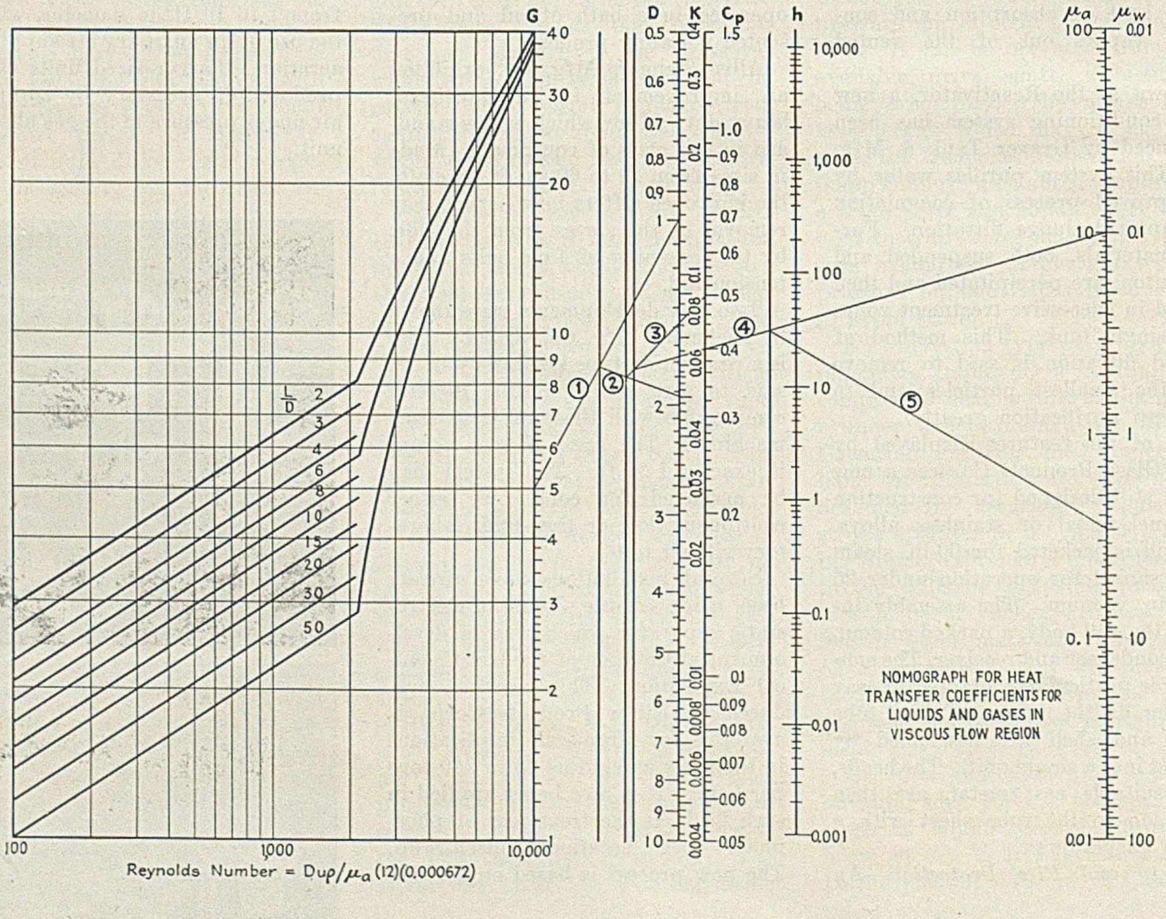
The mathematical relationship is:

$$G = \frac{h\,D}{12\,K}\left(\frac{2.42\;C_p\;\mu_a}{K}\right)^{-1/3}\left(\frac{\mu_a}{\mu_w}\right)^{-0.14}$$

The accompanying nomograph graphically expresses the function G as a function of the Reynolds number, $Re = Du\rho/\mu_a(12)(0.000672)$. In the relationship above, h = coefficient of heat transfer in B.t.u. per hour, sq. ft. and deg. F.; D = inside pipe diameter in inches; K = thermal conductivity in B.t.u. per hour, ft. and deg. F.; C_p = specific heat in B.t.u. per lb. and deg. F.; μ_a = average viscosity in centipoises; μ_w = viscosity at tube wall in centipoises; u = fluid velocity in ft. per sec.; ρ = fluid density in lb. per cu. ft.; and L = heated length of the tube in ft.

As an example of the use of the chart, a liquid is passed through a heat transfer tube having an inside diameter of 1 in. and a heated length of 4 ft. The flow velocity is 1.77 ft. per sec., the liquid density is 50 lb. per cu. ft., and the viscosity at the main stream temperature is 10 centipoises. If the thermal conductivity is 0.05 B.t.u. per hour, ft. and deg. F.; the specific heat is 0.5 B.t.u. per lb. and deg. F.; and the viscosity at the wall temperature is 3 centipoises, what is the liquid film heat transfer coefficient?

Solution: Solving for the Reynolds number, we get (1) (1.77) (50)/(10) (12) (0.000672) = 1,100. At this value, pass upward on the graph to L/D = 4, then horizontally to the G scale. Construct Line 1 connecting G with D = 1. Construct Line 2 connecting the first reference line with K = 0.05. Construct Line 3 connecting the second reference line with C_p = 0.5. Construct Line 4 connecting the third reference line with μ_a = 10. Construct Line 5 connecting the fourth reference line with μ_w = 3. Read the answer, h = 23 B.t.u. per hour, sq. ft. and deg. F., from the intersection with the h scale.



CHEM & MET REPORT ON

War-Time Protection of Industrial Plants

TO CHEMICAL EXECUTIVES, ENGINEERS AND ALL PLANT PERSONNEL

The vital importance of chemicals in the industrial set-up of the nation has been clearly demonstrated: without an adequate supply of chemicals a plane remains unbuilt, a tank lies unused, an army does not advance. And just as important as these chemicals are the industrial plants and trained men that make them possible. Now that America is at war, these plants so precious to the national economy must be protected from the double dangers of enemy attacks from without and traitorous stabs from within. Sabotage, incendiary bombs and incendiarism, enemy air raids: these three, but the greatest of these is sabotage. And of the many forms of sabotage, fire is the most prevalent, the most dangerous, and the most insidious. The plant that immunizes itself against damage from fire, whether intentional or accidental, can survive unscathed the next few years of danger and destruction.

War-Time Protection of Industrial Plants

SUMMARY AND CONCLUSIONS

Sabotage by fire is the most dangerous of all war-time enemies of American chemical and process industries. Fortunately, protection against such damage can be had by strict adherence to orthodox methods of fire prevention, although it will be necessary to double and triple normal peace-time measures. Common sense and stern precautionary steps are the best protections against all types of sabotage and espionage of industrial chemical and process plants.

Enemy air raids may consist of efforts to cripple or destroy certain industrial plants by the use of incendiary bombs. Magnesium incendiaries are relatively harmless if properly understood and fought. A fine spray of water can quickly extinguish them and prevent damage in most cases. However, it is first necessary to have proper equipment in sufficient quantities, properly trained personnel and many sources of water in order to fight such bombs successfully.

Reasonable protection of equipment and personnel from distant effects of high explosive bombs can usually be obtained from light weight shutters and other simple methods. Blackouts can best be accomplished by the use of proper screens or baffles, although most plants require individual study before protective steps are taken.

Protection Against Sabotage

As one means of preventing industrial sabotage, the F.B.I. has been engaged in a plant survey program undertaken to suggest means for protecting the facilities of basic industries whose products are vital to war and the national security. Some 2,400 plants are on this priority list and 1,700 have been surveyed. In addition, 12,000 industrial plants may subsequently be covered by the program. Upon request, surveys of chemical plants having government contracts will be made by the Army, Navy or F.B.I. but no surveys will be made by the Office of Civilian Defense. However, the responsibility of self-protection is largely up to the individual plant.

METHODS OF SABOTAGE

Common forms of sabotage against the chemical and process industries include: (1) damage to machines or equipment by breakage, corrosive chemicals, abrasives or explosives; (2) damage to power stations, water supply, gas mains, or other key points; (3) arson, which includes intentional negligence and the creation of specific fire and explosion hazards; (4) theft or damage to blueprints, formulas, or other confidential matter; (5) damage or destruction to railroad connections, vessels at docks, and other means of transportation; (6) damage to raw materials or finished products and interruptions or upsetting of operating conditions. The last named is the most vulnerable in the chemical and process industries.

Sabotage Bombs—Bombs used by the saboteur are usually either dependent upon physical manipulation or are set to explode at a predetermined time. Under the first classification come impact, tilting, and trigger bombs, the first two types being rarely used. Trigger bombs, if discovered on time and properly handled, may never detonate, and may furnish valuable clues to the identity of the saboteur. The trigger mechanism may be anything from a string stretched across a path or attached to a door to a device which will close an electrical circuit or set off a trigger-hammer mechanism when the package is opened.

Time bombs are the favorite of the saboteur. These may be timed by fuses, clockwork mechanisms, or chemicals, and are particularly dangerous for there is no means of determining when they may explode. Fuses are widely used even though they do not always burn their entire length. If an ordinary alarm clock is used, the elapsed time usually must be less than 12 hours. Chemical bombs depend on the length of time a corrosive acid takes to eat its way through a container to come in contact with an explosive mixture. By varying materials and thicknesses of the containers, ignition can be set days or weeks in advance.

SABOTAGE BY FIRE

Sabotage by fire, the most common and dangerous of all methods, usually involves interference with the fire protection of the property prior to starting the fire. This interference may consist of tampering with fire-fighting equipment by plugging the nozzles, emptying the contents, cutting the discharge hose of extinguishers, or replacing the fluid with flammable liquids. Standpipe and sprinkler systems can be made inoperative by closing valves, removing valve wheels and damaging hose and connections. Burring a thread on hose outlets will make their use impossible unless suitable adapters or universal couplings are carried in stock.

Incendiary Materials—Most sabotage fires are started by use of incendiary devices or chemicals subject to spontaneous ignition. For example, sodium may be placed under openings in the roof or at the bottom of a water spout so that rain would result in ignition of the sodium and adjacent material. Or it may be wrapped in heavy paper and tossed into water near piers. Eventually the water will work through the paper covering and if the floating sodium is in contact with oil-coated piles under a pier, ignition of the pier may result.

An ingenious device for starting fires made its appearance in the last war and consisted of a short piece of lead tubing in the center of which was placed a thin copper disk folded to the tubing around the periphery. In one end was placed picric acid and in the other end sulphuric acid. Both ends of the tube were plugged with wax and capped with lead. The sulphuric acid would eat through one copper disk and upon reaching the picric acid, fire would occur. The most recent adaptation of this device is the "incendiary pencil", which has the appearance of an ordinary pencil and is fitted with lead and eraser. These pencils may be deposited in combustible materials in trains, ships, or stored in plants.

Gases are sometimes used for starting fires although there is danger of premature explosion. The usual plan is to leave an open flame in the room where gas is permitted to escape. When the gas arrives at the fire there is a flash back to the source, which may start a fire in combustible materials at that point.

Celluloid scrap is employed chiefly to accelerate a fire. Ordinary tallow candles are a very common device for starting delayed-action fires, since they burn at the rate of approximately 1.3 in. per hour. Streamers are also commonly employed with candles. The use of volatile and flammable liquids has become more common recently. Rifle fire from outside the premises may start fires in highly flammable chemicals.

Overloading electrical circuits has also been used by saboteurs to cause fire. Since cut-off fuses afford protection against dangerous overloading, the use of "jumpers" or pennies in the cut-off box in place of the fuse may sometimes be linked with sabotage.

PREVENTING FIRE

Eternal vigilance is the best insurance against fires. These can be kept to a minimum by insistence upon removal of all rubbish, careful and constant check-up of personnel and material arriving at the plant, and by daily inspection of standpipes, fire equipment, sprinklers and auxiliary appliances (extinguishers should be so located and sealed that removal or tampering would be quickly detectable). Hose couplings should be examined frequently to insure protection against injured threads.

The first thing the saboteur is likely to do is to close the sprinkler valves. Therefore, although frequent inspection is a good practice, sealing coupled with inspection or automatic electric supervision is still better.

Thorough study should be made of the various sources of auxiliary water and methods of using these in case of damage to the main supply. Unless the water main system is cross-connected and valved, so that any broken section might be segregated, serious bleeding of water may result from pipe rupture.

Storages of highly flammable materials, such as gasoline, oil or certain chemicals should receive special protection because of the serious fire risk and the ease with which saboteurs can exploit this risk. This may involve construction of dikes around tanks, placement of tanks underground or removal to a less dangerous location.

PREVENTING SABOTAGE

Other than the elimination of fire hazards, the following steps are the most important for prevention of industrial sabotage: (1) selection and identification of operating personnel; (2) restrictions and check-ups on visitors; (3) trained guards; (4) protective fencing and lighting; (5) care of confidential documents.

Personnel Identification—Some executives feel that if each employee punches an appropriate time card upon entering and leaving the plant, unauthorized persons are not likely to enter the premises. This is not true. Each employee should be provided with a photo-identification card, preferably of safety paper to prevent alterations, bearing his signature, employment number, and specific plant assignment. This card should be enclosed in a sealed plastic container and prominently displayed on the person at all times. Badges with different colors and shapes to designate plant assignments make it especially difficult for a stranger to move about a chemical plant unnoticed.

Section 2 of the Act of June 28, 1940 provides in part "no aliens employed by a contractor in the performance of secret, confidential or restricted government contracts shall be permitted to have access to the plans or specifications, or the work under such contracts or to participate in the contract trials, unless the written consent of the head of the government department concerned has first been obtained, and any persons who willfully violate or through negligence permit the violation of the provisions of this subsection shall be fined not more than $10,000 or imprisoned not more than five years or both." Chemical manufacturers having government contracts should pay particular attention to the above statute as all violations are their direct responsibility. Manufacturers might do well to remember that persons of German descent have attained a particularly thorough penetration into the chemical industries of this country. While most of these persons are undoubtedly loyal Americans, it is inevitable that some few may be willing to carry on subversive activities.

Guards and Police—The police chief of a chemical plant should be charged with safeguarding the plant and its material from all subversive activities. He should control traffic and maintain a clear route for fire-fighting equipment. The handling of explosive missiles, whether high explosive or incendiary bombs, should be one of his responsibilities and his men should be given special training for this work.

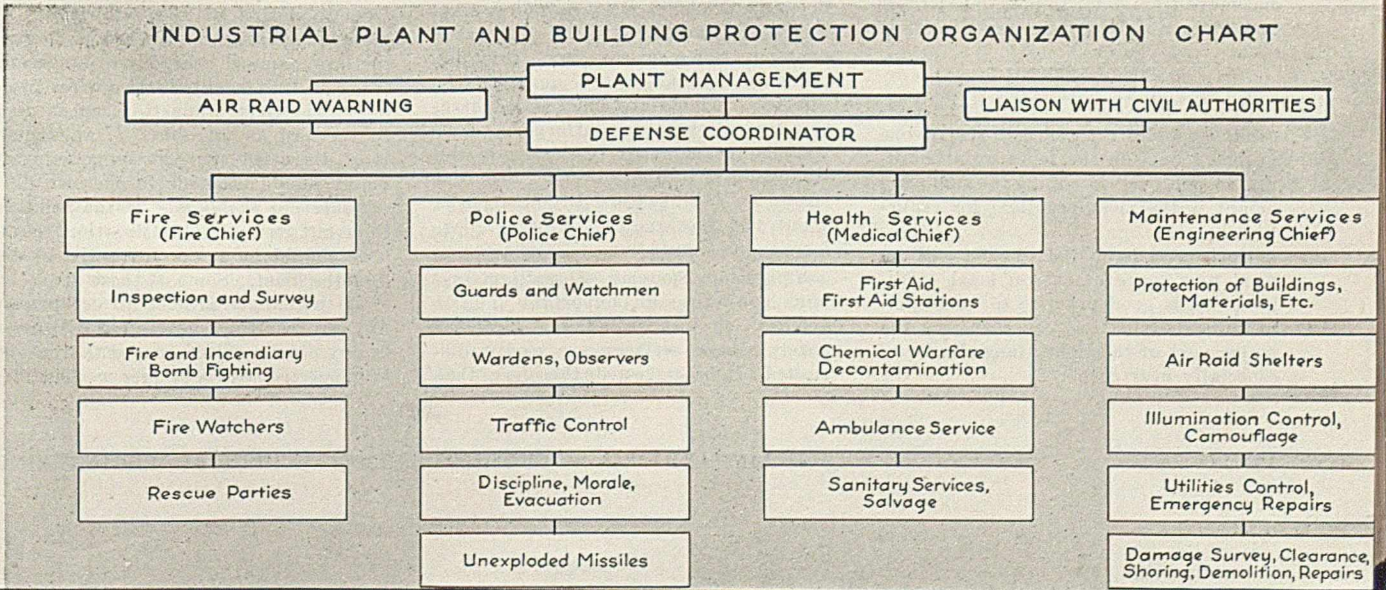
The beat of guards should be changed at irregular intervals. Guards' shifts should not coincide with those of regular employees. All guards should be well trained in the efficient use of the firearms they carry.

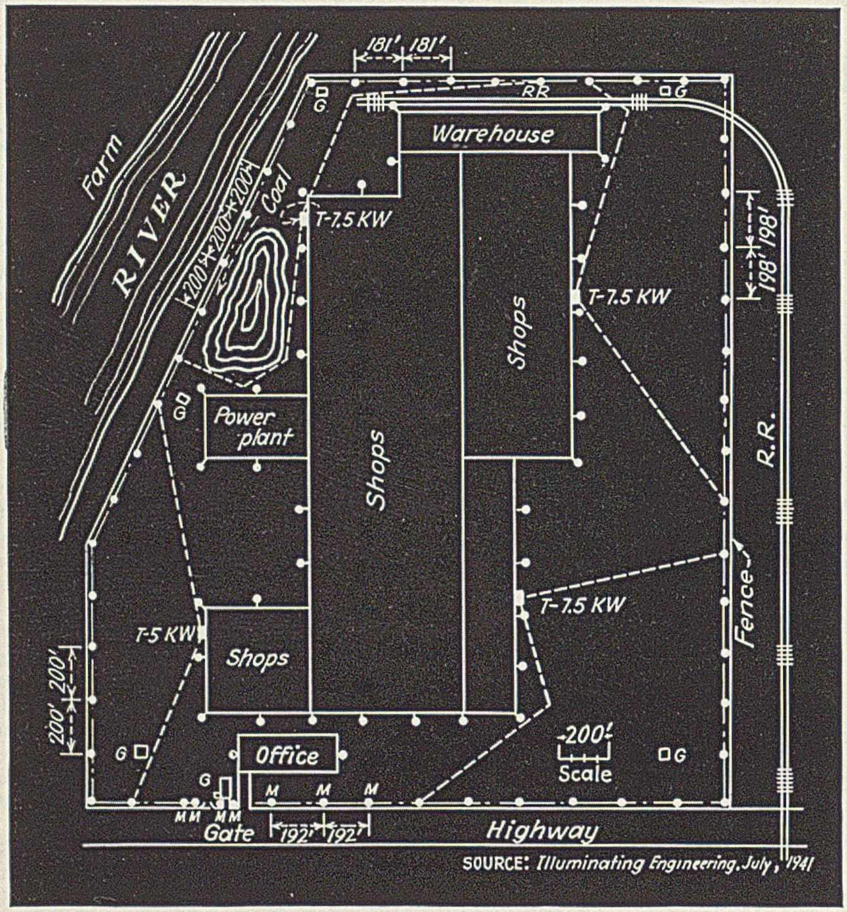
A spot check-up of lunch boxes should be made at frequent intervals and uninspected packages should never be allowed into the plant. A guard should be on watch as trains enter the plant premises, both at the point of entrance and also where box-cars are opened or sealed. An adequate set-up for safe handling of mail and protection of mail-sorting personnel should be adopted. It would be a good idea for plants to change the locks on all gates, be certain that only authorized persons have keys and to alternate locks at intervals.

Adequate repair facilities should be available and placed in locked sheds at strategic locations. Necessary tools should be so arranged as to be readily moved from place to place. Open drains and sewage lines, especially those having intermittent flow, should be barricaded with a grill if the diameter is more than about 2 ft.

PROTECTIVE FENCING

Fencing should be at some distance from the area to be protected, known in military terms as the "throwing distance." The purpose of the fence is to provide a barrier against a *determined* intruder, and it should be erected so as to aid in the conservation of man power if guarding becomes necessary. In cases





Plan of a typical industrial plant showing fence, gate and yard lighting. G indicates the guard shack, *T-7.5k.w.* a constant-current transformer, and *M* shows the lamps on multiple supply. The fence lighting units are mounted 25 ft. above ground and 10,000-lumen, 20-amp. series lamps are used for an illumination of 0.19 footcandle

where it is not possible to locate a fence around a plant area, screens must be provided over windows or other openings in buildings.

Protective Lighting—In making arrangements for protective lighting, a few basic facts should be remembered: (1) lighting or guards alone will not afford protection; (2) indicating devices that register the presence of someone in the plant property where he should not be are not effective; (3) the guard, if possible, should be stationed in a shack and have a telephone and a marine-type concentrating searchlight of 1,000 watts; (4) the guard should not move from place to place; (5) there should be no glare from any direction.

FENCE LIGHTING

Proper fence lighting of 0.15-0.2 footcandles enables the guard to see anyone loitering outside the fence or attempting to get over it. A 25-ft. mounting height is the most practical for reducing the glare.

Horizontal light distribution will depend to a large extent on local conditions. It is good practice to use asymmetrical distribution, concentrating the major part of the light along the fence, especially near corners.

However, in addition to a safely wide spread of light at the gate, there should be down light at 30 deg. from the vertical, aimed at the center of the roadway to make identification quick and positive. Lights near the entrance should be on a separate multiple circuit for additional reliability and many plants are providing a diesel-engine generator set for emergency use.

Inside lights should never be turned on and off by the watchman as he makes his rounds. A low, uniform illumination of 0.25 footcandle is sufficient. For low bays, 200-watt lamps on 70-ft. centers and mounted 12 ft. from the floor are good practice. Shipping platforms are unusually vulnerable since men on trucks or cars are often not plant employees and large quantities of finished products are congregated here. One typical shipping platform has 200-watt lamps mounted vertically on the side walls 12 ft. above the platform and spaced on 35-ft. centers. Illumination is about two footcandles. Shipping platform lights should burn all night.

Signalling Systems—Signalling systems constitute an important line of defense against sabotage. Unfortunately, these services are easily disrupted. It is suggested, therefore, that chemical plants undertake surveys of their normal and emergency signalling systems in order to ascertain whether those services need guarding or supplementing. Spare parts for the most vulnerable pieces of equipment should be on hand. A survey in each plant will determine the means for coordinating facilities with those of the municipality.

Underground lines, which are normally more protected than those overhead, can be sabotaged by dropping acid, bombs or other destructive agencies into manholes. These acts are less likely to be observed than would those against overhead lines. Hence all manhole covers should be locked and cables should be covered with acid-resistant shields, where feasible. Only authorized persons should ever be allowed to open a manhole, work in it or be near it when it is open.

In Case of Sabotage—Any plant owner, superintendent or foreman should immediately report to the nearest office of the F.B.I. details of any information indicating the possible violation of sabotage or espionage laws. No attempt at evaluation or investigation of the information should be made. Suspicious circumstances should never be discussed. Particular attention must be paid to collecting and preserving all possible clues, and detailed reports should be written on the spot as these may later prove invaluable in ascertaining and convicting the saboteur and any accomplices in the plant.

HANDLING SABOTAGE BOMBS

There is no safe way for handling an unexploded bomb. It was deliberately designed that way. Experience, however, has shown that the damage from such bombs can be limited by barricades, blasting mats, sand bags and trenches.

First thing to do on discovering a suspected bomb is to decide whether or not to move it. This is determined by the amount of damage the bomb is likely to do. The amount of unburned fuse can often be ascertained at a glance, and a guess of the time available based on the fact that standard safety fuse burns at a rate of one foot in 30-40 seconds. If the fuse is pulled out, speed and promptness are essential. The fuse should be thrown in a safe direction instantly to avoid injury from explosion of the detonator. In an open bomb, if the wiring and detonator are exposed, the least dangerous thing to do is to cut the two wires leading to the electric blasting cap as near to the cap as possible. If the bomb is of disguised type, no immediate attempt should be made to open it.

Deflecting the Blast—If the bomb is to be left in its original location, measures should be taken instantly to deflect the blast. Some of these are: (1) clear the danger area of all occupants; (2) see that the bomb is not disturbed or any nearby objects moved that might be connected with a trigger mechanism;

(3) establish an organized guard around the danger area; (4) open all doors and windows to allow any blast to disperse; (5) surround the bomb with sandbags or felt mattresses (without metal springs) to direct the blast in the direction where it will do least harm; (6) remove all flammable materials from the area and shut off gas, electric, steam and compressed air lines; (7) salvage valuable machinery or equipment.

If the bomb is to be moved, the following suggestions may be helpful: (1) avoid turning it on its side or upside down; (2) a heavy felt mattress will afford a certain amount of protection if kept between the operator and the bomb; (3) occasionally a bomb can be moved by dragging it with a rope at least 50 ft. long; (4) gloves worn by the operator will aid in preserving fingerprints.

Never Put Bombs in Water—If a bomb contains an electrical mechanism, water may cause a short circuit and result in detonation. Or it may contain a metal that bursts into flame in contact with water, or an acid that is affected by water. Even a fuse and dynamite bomb will not be affected by water if a water-proof fuse and blasting gelatine are used. If it is essential to use some quenching agent, light lubricating oil or coal oil are the best. The oil tends to stop the clockwork mechanism. Gasoline is also recommended as readily available and efficient in deadening the dynamite.

Dangers in Opening—It is extremely hazardous for unskilled persons to attempt to open or even handle unexploded bombs. Only the expert will remember that the obvious or intended way is usually the wrong way. A suspicious package wrapped in paper and tied with a string should be opened by leaving the string intact and cutting a hole through the paper. If it is a box with a lid, all catches and the lid should be left untouched, and an opening made in the end or the bottom of the package.

Gathering Evidence—Extreme care should be taken before and after an explosion to gather all evidence that may aid in identification of the saboteur. The following steps should be taken: (1) care should be exercised not to add or destroy fingerprints; (2) the bomb should be photographed in its original location from various angles; (3) the package should be examined by X-ray, using a fluoroscope, to show up objects such as clock-work and trigger mechanisms; (4) extensive notes should be taken on the spot; (5) witnesses should be questioned as to the sound of explosion, amount and color of flash, smoke and violence of the concussion as evidenced by ringing of the ears (this will indicate if it was a low explosive such as illuminating gas or blasting powder, or high explosive such as dynamite, nitro-glycerine, guncotton, or TNT; (6) all fragments of wire, clockwork, burned fuse, pipes, etc., should be carefully preserved.

Protection Against Incendiarism

EVERY CHEMICAL and process plant should arrange with neighboring plants and communities for mutual aid in an emergency by listing special hazardous processes, fire fighting equipment and arranging for hose adapters if different types of threads are used. A well-ordered mutual aid plan also includes a roster of skilled workers such as engineers, mechanics, welders and electricians. One example of such co-operation is given by the Allis-Chalmers Mfg. Co. in Wisconsin. This plant calls the entire personnel of the municipal fire department for a personally conducted tour throughout the plant once a year. Firemen likely to be called to that plant know what to do immediately.

PRECAUTIONS AGAINST FIRE

However, there must also be independent organization and training of private brigades in chemical plants, for the municipal and neighboring fire departments will no doubt be too busy to help in the event of fires from incendiary bombs.

Over 20 fires that occurred during the first six months of 1941 which resulted in damages of $200,000-$5,000,000 were due to the following: (1) excessive concentration of combustibles and damageable stocks; (2) fighting of fire by employees instead of summoning the fire department; (3) watchman's delay in calling the fire department; (4) improper valve supervision; (5) removal of protective features such as fire walls and sprinklers; (6) lack of protection from special hazards; (7) inadequate water supply; (8) laxity of management in providing rigid fire protection.

Members of the fire brigade should realize that in case of fire, the sprinkler control valves must be examined to see that they are opened wide. Records over 50 years show that sprinkler performance throughout the country has had an overall efficiency of 96 percent. The failures were primarily due to lack of maintenance or closed valves. Drills should include the making of hose connections, unreeling and stretching hose without kinks, and coupling and uncoupling.

The best precaution against the spreading of fires is a sufficient number of shut-offs for all gas lines, additional switches for electrical lines, and by-passes and valves for water pipes. A sufficient amount of pipe and fittings and electrical appliances should be on hand for the prompt repair of all lines.

Cotton and rubber-lined hose should have water run through them at least four times per year and pressure tests should be applied at least once per year. Linen hose should be kept clean and dry. Plants having electrically driven fire pumps with power obtained from outside may find it desirable to purchase an auxiliary gasoline or diesel engine pump.

Normal concrete construction is more resistant to fires than the unprotected steel work often found in chemical plants. In some cases it might be wise to cover exposed steel or wood in highly vulnerable areas with a metal lath and cement plaster coat. In England, it is reported that for every ton of structural steel irreparably damaged by explosive bombs, 10 tons are destroyed by fire.

Woodwork can be protected to some extent by the use of certain inorganic salts and fire retardant paints. Tanks storing flammable chemicals should be mounded to avoid spreading burning liquids over large areas and adequate fire walls should be provided so as to localize fires within buildings. Packing materials, gaskets and other rubber stocks, small quantities of paint, rope and wrapping materials when stored in orderly fashion are not considered a serious menace. Oakum, lamp black, some welding compounds and cleaning fluids can be sources of fire and must be treated accordingly. Paint storage in bulk creates a special problem as the use of wooden barrels for shipping results in leakage of linseed oil.

Table I—Emergency Incendiary Fighting Equipment[1]

Four 3-gal. buckets.
1 hand pump, stirrup type, with 30 ft. of ½-in. hose and dual jet-spray nozzle.
1 extension ladder.
1 long-handled shovel.
1 long-handled scoop and hoe.
1 hand ax.
1 pair heavy gloves.
1 large flashlight or oil lantern.
1 fire-fighting mask.
1 soda-acid fire extinguisher.

[1]Civil Air Defense, by A. M. Prentiss, McGraw-Hill Book Co., New York (1941).

Table II—Penetration of Magnesium Incendiary Bombs[1]

Weight of Bomb, lbs.	Inches of Penetration[2]: Reinforced Concrete	Sand	Earth	Mild Steel Plate
2.2	3.5–4	6	6	0.25
4.3	5–6	42	60	0.38
12.0	.....	57	84	....
22.0	.....	72	108	1.0

[1]Chemical Warfare School, Edgewood Arsenal.

[2]Approximate. Represents minimum thickness of material required to resist penetration.

Table III—Floor Protective Materials Against Burning Magnesium Incendiary Bombs[1]

Material	Minimum Layer For Protection, in.
Brick dust	1.5
Slate dust	1.3
Foamed slag (ground)	2.0
Pumice (ground)	1.3
Household ash	2.3
Boilerhouse ash	1.8
Kaolin	1.5
Limestone (ground)	1.3
Asbestos wallboard	0.8
Ash or ballast concrete	1.0
Gypsum comp. (certain types)	0.8

[1] 2-lb. size. From "Incendiary Bombs and Fire Precautions", British Government.

A heavy bomber can carry from 1,000-2,000 of 2.2 lb. magnesium incendiary bombs. In large towns, out of every 12 bombs dropped, 10 would probably fall in open spaces and burn without serious damage. Of the remaining two, one would probably glance off a sloping roof or fail to function so that no more than one out of a dozen would start a serious fire. Thus 75-80 fires might be started along a distance of about 3 miles, or an average of one fire every 60-70 yd.

MAGNESIUM INCENDIARY BOMBS

Ignition of magnesium incendiary bombs occurs on impact. The starting mixture ignites the thermit of which the aluminum burns violently, robbing the iron oxide of its oxygen. This furnishes intense heat for 40-50 seconds and produces molten iron, the pressure of which causes spattering of the iron and of burning pieces of magnesium. The burning thermit ignites the magnesium body, which continues to burn quietly for 10, 15 or even 20 minutes. The burning of the magnesium itself is easily detected as there is less spattering and an intensely white flame is produced. These bombs often carry a high explosive in order to discourage extinguishment. However, after two minutes of burning there is little danger from such explosives.

Protection—Floors of attics should be covered with non-flammable material such as a 2-2½ in. layer of dry sand or earth or by a sheet of 20-gage corrugated iron insulated from the floor by a thin layer of sand or earth. Chicken wire stretched about 1-2 feet above the floor helps in breaking the impact of the bomb and in dispersing it. Rafters and joints in the attic or top floor should be coated with fire-resistant paint or heavy whitewash.

Every small building and every 8,000 sq. ft. area of large buildings should be provided with the following emergency supplies: four 3-gal. buckets, two for sand and two for water; one hand pump with 30 ft. of ½ in. hose and a dual jet-spray nozzle; one extension ladder; one long-handled shovel; one long-handled scoop and hoe for removing bombs; one hand ax; one pair of heavy gloves; one large flashlight or oil lantern; one fire-fighting mask; one soda-acid chemical fire extinguisher.

The British have found that a 2-lb. incendiary bomb can penetrate 4 in. of reinforced concrete or ½ in. of mild steel plate and it therefore may penetrate a plank-on-timber roof, depending on the slope of the roof and the angle of impact. A bomb will often burn through a ⅞ in. board flooring.

Extinguishment—It is dangerous to approach a magnesium bomb for about a minute after ignition because of the spattering effect; molten metal may be thrown as far as 50 ft. during this phase. A solid stream of water should never be directed on the bomb while the thermit is burning, since it produces an explosive effect on striking the molten mass, thus spreading the fire. Water spray on burning thermit has little effect since thermit supplies its own oxygen and cannot be smothered, while the high temperature of the combustion makes cooling impossible. A *stream* of water should not be directed on the bomb when the magnesium itself is burning. A solid stream of water striking this hot metal (3300 deg. F.) scatters the material with explosive force due to the formation of steam and to the rapid chemical reaction of water and magnesium to liberate hydrogen.

However, a water *spray* on burning magnesium is very effective because of the following actions: (1) in contact with the burning metal, the water spray is converted to steam, thereby producing a cooling effect; (2) the blanket of steam above the fire helps dilute the 21 percent oxygen in the air to a point below 16 percent necessary for combustion; (3) burning of the bomb is accelerated and thus may be reduced 10 minutes or more; (4) the floor and surrounding combustible materials are wetted and cooled.

SPRAYING EQUIPMENT

For spraying magnesium bombs with water, the British use a stirrup hand pump equipped with 30 ft. of hose and a ½ in. nozzle giving a jet carrying 30 ft. or a spray carrying 15 ft. Two or three people may be required; one handling the nozzle, one pumping and one replenishing the water. The man with the nozzle approaches the bomb and first extinguishes any fire which may have been started, by playing a *stream* of water directly upon the secondary fire. As soon as this fire has been put out a *spray* is used on the bomb itself. It is generally necessary to use 6-7 gal. of water for each bomb. However, the stream from a large fire hose is sufficiently strong to be played directly on the bomb, and if there is sufficient volume of water, it may be consumed completely in a few seconds.

The knapsack type extinguisher with a 5-gal. portable tank curved to fit the back is fitted with a hand-operated piston pump. This is a one-man extinguisher and has proved effective, although it has the disadvantage of sometimes having to be refilled with water while in use. A soda-acid extinguisher is about as effective in extinguishing magnesium fires as plain water in equivalent amounts.

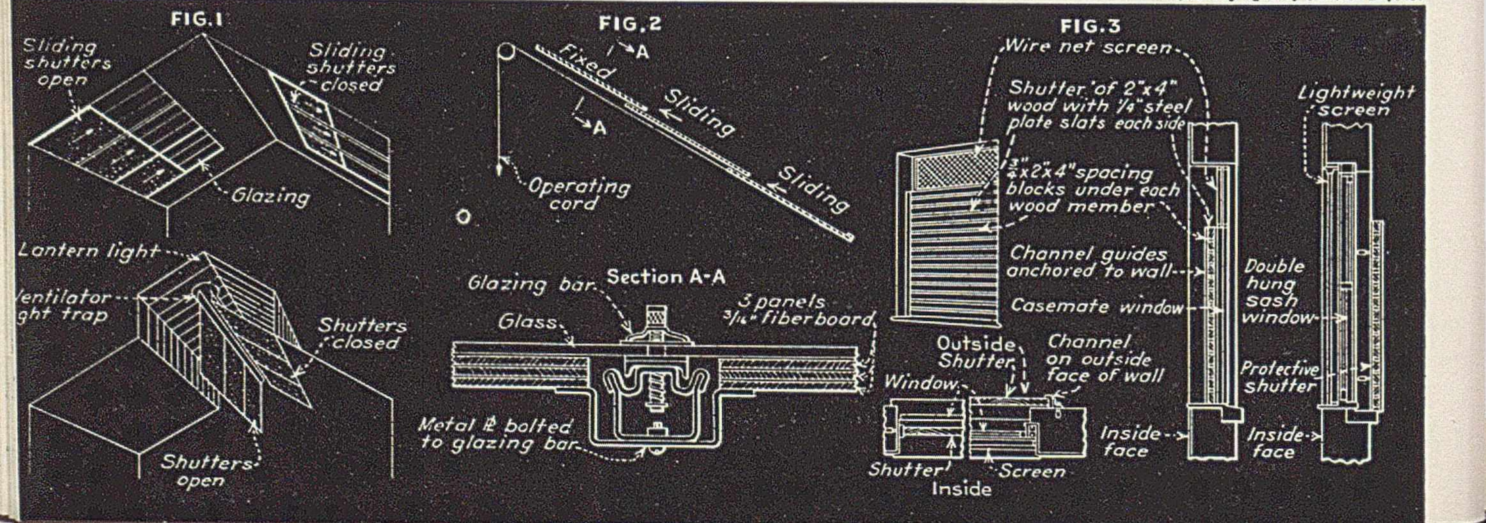
Commercial fire resistant powders, talc, or fine sand, provided they are dry, can be used to cover burning magnesium bombs. However, such materials should be used only when the bomb is burning on a solid floor with little combustible material nearby. If possible, the fighter should be protected with a mask or gas-tight goggles and heavy gloves. Half a bucket of sand is placed on the floor near the bomb, and

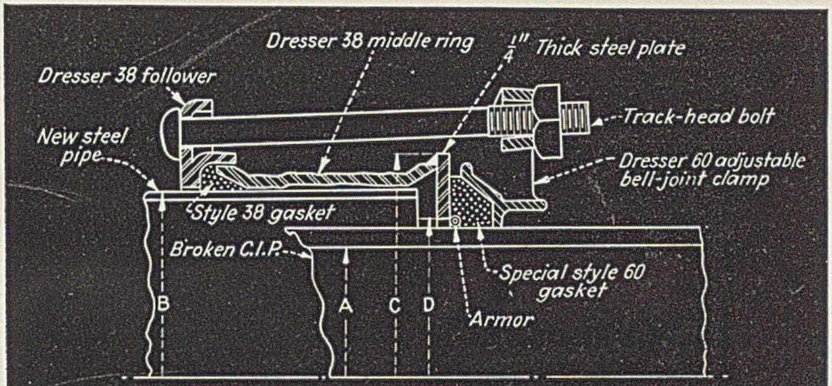
Fig. 1—Two general schemes for the obscuration of sky lights in industrial buildings are shown in these sketches

Fig. 2—This type of internal sliding shutter for blackout is estimated to cost about $0.50 per sq. ft. installed

Fig. 3—A steel and wood inside shutter such as this will provide medium protection from fragments

Courtesy Office of Civilian Defense





Specifications

C.I.P. SIZE "A" DIA.	STEEL PIPE O.D. "B"	MIDDLE RING	FOLOWER THICKNESS	STYLE 38 G'SKT. SEC.	BOLTS	STL. PLATE	
						DIA."C"	DIA."D"
3	5 9/16	1/4 x 5	1/4	1/2 x 1	4-5/8 x 9	6 3/4	4.085
4	6 5/8	1/4 x 5	1/4	1/2 x 1	4-5/8 x 9	7 3/4	5.185
6	8 5/8	1/4 x 5	1/4	1/2 x 1	6-5/8 x 9 1/2	9 3/4	7.285
8	10 3/4	1/4 x 5	1/4	1/2 x 1	6-5/8 x 9 1/2	12	9.485
10	12 3/4	1/4 x 5	1/4	1/2 x 1	8-5/8 x 9 1/2	14	11.585
12	16	1/4 x 7	1/4	1/2 x 1 1/8	8-5/8 x 12	17 1/4	13.685
14	18	1/4 x 7	1/4	1/2 x 1 1/8	9-5/8 x 12	19 1/4	15.835

The modified Dresser couplings and sleeves, known as air-defense fitting No. 1, makes it unnecessary to square the ends of severed 3-14 in. cast-iron mains or to remove any of the pipe no matter how far back cracks might extend. In demonstration, repairs were completed in 15 min. by the use of this fitting. Other emergency measures for closing main breaks are discussed in *Gas Age*, Nov. 20, 1941

the operator places sand around and on top of the bomb with a long-handled shovel. It is then possible to shovel it into the bucket on top of the remaining sand, and then cover with sand. The bucket is then removed by use of the shovel handle or a long stick.

The sand method should be used only after all thermit has burned out. Sand and other abrasive materials should be kept away from moving machinery. Granulated pitch, experimentally, offers promise of being an excellent extinguisher. A snuffer will stop flying particles of molten metal and will confine the heat so that the operator can approach, but the bomb will continue to burn vigorously beneath the snuffer and may cause serious damage unless soon removed.

Protection Against Air Raids

Every chemical plant must be prepared to take care of itself without asking for municipal help although collective action by groups of neighboring companies is advisable in industrial centers. As the Office of Civilian Defense does not recommend immediate building of large bomb-proof shelters, since what raids are expected will probably be sporadic, plants should give particular attention to protection of personnel. Employees taking defense courses at industrial plants after working hours should not expect to be paid for such activities if these are connected in any manner with the problem of personal safety.

In large factories, it is a good idea to assign employees in a particular section a definite color scheme and then to have markings in the plant so that if each employee follows his own color markings, he will arrive at his designated shelter. This scheme eliminates verbal instructions and prevents men from going to the wrong shelter or losing their way. The knowledge that safe shelters have been provided increases morale before and during air raids.

Shelters — Steel or concrete frame buildings are relatively safe from anything but a direct hit from a high explosive bomb. Most modern office and factory buildings of more than four stories and of reinforced concrete or steel frame construction offer suitable locations for shelters within the building. The room selected for a refuge should have its ceiling strengthened to support any debris which may fall upon it. English and German specifications require strengthening to carry a load from 200-400 lb. per sq. ft. in masonry buildings. In frame buildings, this could probably be somewhat less. Lateral protection can be obtained by closing windows and doors with concrete, brick or sandbags. No gas or steam conduits should enter or pass through the room.

If multi-story buildings are to be used as shelters, the following features should be avoided: large proportion of voids to solids in external walls; one-cell floors with no partitions between external walls; timber floors or floors of weak construction; buildings of doubtful lateral strength; skylights or glass roofs; heavy objects such as storage tanks or machinery on top floors; high chimneys at or above the roof level.

PROTECTION FROM AERIAL BOMBS

Protection from fragments of bombs which fall not closer than 50 ft. is given by 30 in. of earth or sandbags, 13 in. of brick, or 1.5 in. of steel plate. Glass embedded with wire mesh is only slightly more resistant to blast than plain glass, but the splintering effect is considerably less. Laminated glass also reduces splintering but may be blown out completely.

Shutters—A reasonable amount of protection from 75 percent of the fragments from heavy bombs can be provided by shutters of ½ in. mild steel. Wood shutters ⅜ in. thick will provide fair protection from glass at distances from 50-200 ft. where windows are partly shielded by adjacent walls. To withstand blasting effects, shutters should be held firmly, preferably in steel channels anchored with bolts. For very large windows, a strong frame may be placed on the outside to break the openings into several smaller openings to each of which a shutter should be attached.

There is no sure way to prevent the breakage of glass from distant effects, such as air blast and earth vibrations. However, of the several treatments for the protection of glass, those which have proved most resistant include burlap-bituminous treatment, wire mesh and screens, wired glass, and controllable shutters. For further construction details, "Glass and Glass Substitutes" should be consulted.

Protection of windows from near effects of high explosives requires the consideration of both the blast itself as well as fragments. For this reason, extensive measures for such protection are necessary and the complete removal of windows and the use of substitutes such as blocking with brickwork, gravel-filled planking, and sandbags may be necessary. For most plants, the risk of near effects should be accepted, as only protection against distant effects is practicable.

REPAIRING MAINS

Broken, bombed or impaired gas mains can be valved or plugged off by the use of conical-shaped plugs suspended on a steel cable across the bomb crater. The plug can be lowered to the end of the broken main and a cup-shaped piece of steel welded to the plug end of the cone enables one man to push the plug inside the main. Gas mains can also be plugged with an air-inflated bag. With the use of this method, it is necessary that standpipes occur at frequent intervals in order to enable the operator to fit the bag into the main quickly. Greasing off will plug up to 12-in. low-pressure mains. This method has the disadvantage of leaving the pipe with a large amount of heavy grease inside with no means of removing it other than digging up the main.

A new coupling and sleeve, designed by Dresser, enables emergency repairs on a broken main without sawing off the jagged ends. This improved design, known as Air Defense Fitting No. 1, is shown in an accompanying drawing. In demonstration, repairs were made in 15 min. by use of this fitting.

BLACKOUT OF CHEMICAL PLANTS

To stage a "blackout" without proper equipment and trained personnel only creates dangerous confusion. Except for immediate contingencies, little or nothing can be done to increase the effectiveness of a blackout while a raid is in progress. "Blackout" (see references) has been published by the Office of Civilian Defense to suggest how certain typical installations may be effectively blacked out. This information is the most authoritative available but is intended to be modified and adapted to each specific plant.

In most types of construction, opaque shutters can be built over all windows, light-locks provided at entrances and provision made for thorough ventilation and prevention of condensation. Outside lights should be covered with blue shades, and white guide lines should be painted where necessary.

Simplest way of blacking out is to spray on paint internally or externally. Paint selected for this purpose should be waterproof and sufficiently opaque in one coat only. As the cost of removing ordinary paint may be three or more times the cost of applying it, any paint used should be removable by a convenient and inexpensive process. External application of paint by sprayers is usually cheapest and best, as it prevents glare from the glass and, if properly selected, will assist in camouflage.

A suitable paint can be made up of 100 lbs. of black ground in oil, 50 lbs. of paste dryer, 2 gal. of turpentine, ½ gal. boiled linseed oil, and 1 pint of terebene, giving 10 gals. of blackout paint.

A suitable stripper would consist of 5 gal. of benzene, 3.3 gal. of acetone and 15 lbs. paraffin wax to give 10 gal. of paint remover. Glass can be painted with blackout plack paint at about $12.00 per 100 lb. can having a covering capacity of 400-500 sq.yd.

Aluminum painted storage tanks, water towers, tank cars, marble or other light stone structures, tin roofs or light concrete walls, and other light reflecting surfaces should be painted or otherwise treated to produce a dark rough mat surface.

Sugar refineries, oil fields and refineries, brick and pottery works and power and utility plants may produce some glow, depending on the type of process and efficiency of operations. The iron and steel industry furnishes the best example. In full operation, these mills and their slag dumps are sometimes visible from the air at a distance of 25 miles or more. Another major problem is concealing the glow from beehive or byproduct coke ovens in operation. To erect covered obscuring sheds over this type of plant would be difficult nor would it be easy to extinguish these ovens quickly. The lengths of such batteries and the amount of glow therefrom make them easy to recognize from the air.

Glare from blast furnaces can be screened by use of large fireproof louvered hoods carried over the charging platforms and kiln chimneys can be dealt with by the use of asbestos sheet baffles. In oil fields, lights and gas flares can be quickly eliminated. However, heavy gases released without flaring in still damp weather do not rise rapidly and constitute a definite fire hazard. In this event, operators should close in the well or extend the flare line by a riser. For large gas volumes disposed of through a single line, such risers might have to be 40-50 ft. high. However, there is no general method of preventing glow suitable for universal application and each plant must be examined and dealt with individually to prevent costly mistakes.

Magnesium incendiary bombs such as this are extensively used by the Germans. They can best be extinguished by applying a fine spray of water

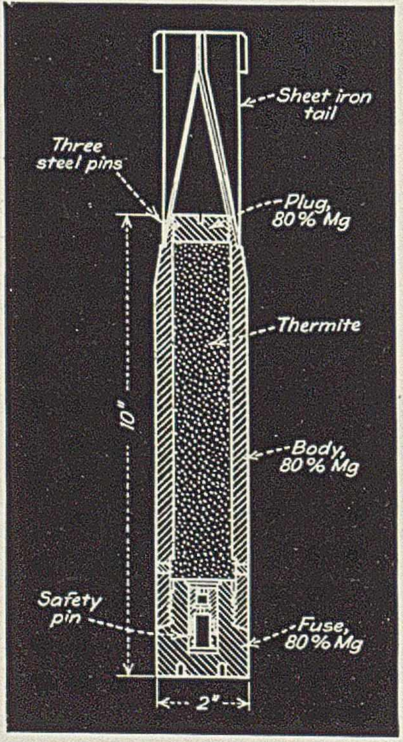


Table IV—Protection Against Bomb Fragments[1]

Material	Required Thickness, Inches[2]
Mild steel plate	1.5
Brick wall	13.5
Plain concrete	15.0
Reinforced concrete[3]	12.0
Specially reinforced concrete[4]	10.0
Sand or earth revetment	30.0
Gravel or stone between wood sheathing or corrugated iron	24.0

[1] From "Protective Construction". Structure Series Bull. 1. Office of Civilian Defense.
[2] For protection against fragments of a 500-lb. bomb at a distance of 50 ft.
[3] Normal structural reinforcement.
[4] Reinforced to resist high local stresses in diagonal tension.

Warning — Plant men considering blackout preparations or other air raid precautions should not contact the Office of Civilian Defense in Washington, but should first consult with their city, county or state Defense Council. Plants having Army and Navy contracts and considered vulnerable to an attack have already received instructions. Under any circumstances, however, it is advisable to become thoroughly familiar with the information already available (see bibliography) before making elaborate preparations for blackout or protection from high explosive bombs. Mistakes are easy to make and can be expensive, time consuming and wasteful of vital materials.

Bibliography

The Office of Civilian Defense has issued a variety of pamphlets and instructions, among which the following may prove of most interest to the chemical and process industries. All responsible plant men are urged to obtain copies of these publications.

A Handbook for Air Raid Wardens. 10 cents.

Protective Construction. Structures Series, Bulletin No. 1. 25 cents.

Suggestions for State and Local Fire Defense. Fire Series Bulletin No. 1. 10 cents.

Protection of Industrial Plants and Public Buildings.

OCD News Letter. Official Bulletin of the Office of Civilian Defense issued approximately fortnightly.

Emergency Medical Service for Civilian Defense. Medical Division Bulletin No. 1.

Air Raid Warning System.

Blackouts. 25 cents.

Civilian Protection; How to Organize it in your Community.

Glass and Glass Substitutes. Protective Construction Series 1. 10 cents.

A Civilian Defense Volunteer Office; What it is, How it is Set Up, What it Does, How to Organize it.

Memorandum on Municipal Signaling Systems. 10 cents.

Instructor's Outline. First Aid Course for Civilian Defense. Issued by American National Red Cross in cooperation with Medical Division, OCD.

Advanced First Aid for Civilian Defense.

Where no price is indicated, orders may be placed with Office of Civilian Defense, Washington, D. C. Where price is indicated, purchase should be made from Superintendent of Documents, Government Printing Office, Washington, D. C., with advance remittance.

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.

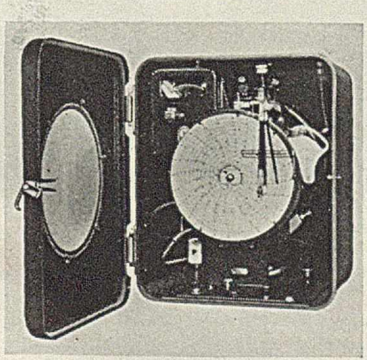
Machinery, Materials and Products

CHEM & MET PROCESS EQUIPMENT NEWS

Ring Balance Meters

EMPLOYING the ring balance principle in the construction of flowmeter manometers, the Ring Balance Instrument Co., 740 North Franklin St., Chicago, Ill., has introduced a line of indicating, recording and integrating mechanical flowmeters which are readily adjusted to meet a range of capacities without dismantling the instrument. These instruments are built in two basic types, one for low-differential, low-pressure applications, and the other for high-differential, high-pressure applications. Differential pressure from the primary element (orifice or venturi tube) is conducted through flexible, self-compensating tubes to the two sides of a ring balanced in a vertical plane on a knife edge bearing. A sealing liquid in the lower half of the ring is displaced proportional to the differential existing in the two chambers above the liquid formed by a partition at the top of the ring. Attached to the lower side of the ring is a range weight (which is easily changed to change the range of the instrument), this weight producing a torque when the ring moves under the influence of an unbalanced differential pressure to achieve a definite equilibrium position for each differential. Motion of the ring balance is transmitted to the recorder pen through a cam mechanism which compensates for the square root relationship. A simple integrator mechanism is available, operating on the ratchet principle, which drives the integrating counter through an index wheel having 1,800 teeth and so operated that a movement of one tooth corresponds to but one-sixth of 1 percent of the total flow reading.

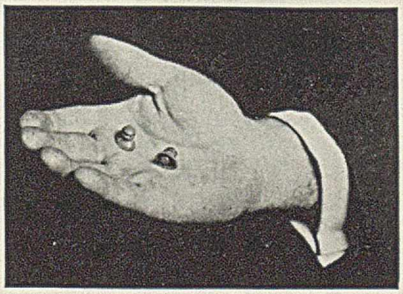
Ring balance flowmeter



Noise Shields

FOR PROTECTING workers against fatigue, irritability and nervous exhaustion, resulting from excessive industrial noise, Mine Safety Appliances Co., Braddock, Thomas & Meade Sts., Pittsburgh, Pa., has introduced a new type of ear plugs known as MSA Ear Defenders which are said to reduce loud noises to about one-tenth their former loudness, yet to permit hearing of warning signals and conversation. These plugs, introduced after long research by recognized authorities in the field of acoustics and industrial health, consist of a tapered tube molded from surgical type soft rubber, consisting of two barriers, an outer one of metal and an inner one of soft rubber, separated by an air space. Design permits easy insertion and removal without danger to the ear drum. Each pair is packed in a plastic pocket container in which the Ear Defenders may be kept when not in use.

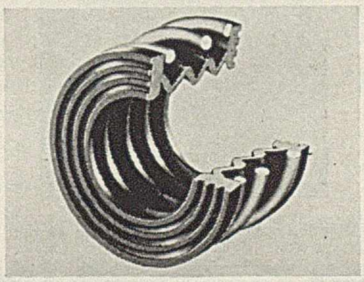
Noise-reducing ear plugs



Bellows Pump Seal

SEVERAL new features are incorporated in a new bellows type pump seal developed by the Crane Packing Co., 1800 Cuyler Ave., Chicago, Ill. As shown in the accompanying illustration, the seal consists of but two parts, a bellows with flanged ends formed from a special synthetic rubber compound, and a spring bearing against the inside shoulders of the flanged ends to hold the contact facings against the sealing washer on the one end and the driving base on the other. Serrated contact facings formed in a series of concentric grooves and flat-faced ribs are said to produce effective sealing action. The seal can be installed readily in difficult positions, according to the manufacturer, since it cannot be installed incorrectly. It is said to be suitable for use in contact with a wide variety of liquids including greases, oils, alcohols, etc.

Bellows pump seal



Oven Collecting Main

A NEW DEVELOPMENT, described as a basic improvement in byproduct coke oven design, has been announced by the Otto Construction Corp., 500 Fifth Ave., New York, N. Y. This is a compensating collecting main system which balances pressure and controls the temperature of the gas at the top of the charge. The system conveys the gas from freshly charged ovens, when the gas is rich and abundant and comes off at a rate which builds up pressure, across the tops of ovens that are in the final stages of distillation. Thus it decreases the temperature and equalizes the pressure and so keeps the entire gas take-off properly balanced. Control of gas flow in the main and in the oven above the coal charge is said thus to be improved. Regulation is automatic, requiring no adjustment at the riser pipes during operation. This system is said to increase the yield of tar up to 10 per cent, to give up to 15 per cent better yield of benzol, and to increase the production of the toluol fraction up to 20 per cent.

Infra-Red Lamp

FOR USE in heating and drying operations employing infra-red radiation, the Birdseye Research Laboratories of Wabash Appliance Corp., Brook-

Bullseye infra-red lamp

lyn, N. Y., has announced a new type of radiant heat lamp, said to make possible 100 percent control of heating efficiency. The new design puts to practical use for heating what is termed the "spilled heat" lost in ordinary combinations of heating lamps and commercial reflectors. The company points out that although many efficient heating reflectors provide convergent, parallel or divergent heat beams as needed, there is still an average of 25 percent of the heat rays that are spilled outside the control of the reflector. The new lamp, known as the Bullseye type, employs a ring lining of pure silver to prevent this loss. The ring is sealed inside the bulb at a location just below the focal point of the filament, reflecting the formerly spilled heat rays into the control area of the reflector which projects them down to the heating area. The new lamp is of 250-watt size, with tungsten filament, designed to fit a standard Edison screw socket.

Drum Opener

OPERATING on the same principle as a can opener, a new semi-automatic drum opener announced by the Turner & Seymour Mfg. Co., Torrington, Conn., is said to be easy and speedy in use and to eliminate the injuries associated with the usual hammer and cold chisel method of opening drums. Known as the Westco Drum Opener, the new machine cuts a smooth-edged opening in straight-chime metal drums up to 35 in. in height. The corrugated cast iron base can be bolted to the floor. Four steel uprights support the cutting unit which is counterbalanced for easy adjustment to the height of the drum. After adjustment the cutting unit is locked in position. By closing the cutting unit lever, the drum is perforated, after which turning the crank cuts the head out.

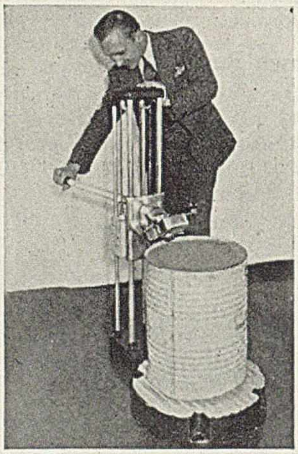
Special Conveyors

TWO NEW TYPES of conveyors designed especially for use in defense industries have been announced by Standard Conveyor Co., North St. Paul, Minn. One is a wood roller conveyor designed for handling explosives in ammunition and armament plants. Both rollers and frames are made of maple, with metal parts of brass or bronze to prevent sparking. Bearings are either of the ball type or of oiless bronze. The second new conveyor is a portable belt piler equipped with rubber-tired wheels for piling, loading and unloading boxcars. The machine is readily removed from one site to another by simply hooking the lower end to a motor truck. A crank on one side is provided for raising and lowering the carrier which in a typical model has a recommended piling height of 8 ft. although it will pile to 10 ft., with 4 ft. as the minimum piling height. The conveyor is equipped with rough-top belting to prevent commodities from slipping when the conveyor is set for high elevation piling.

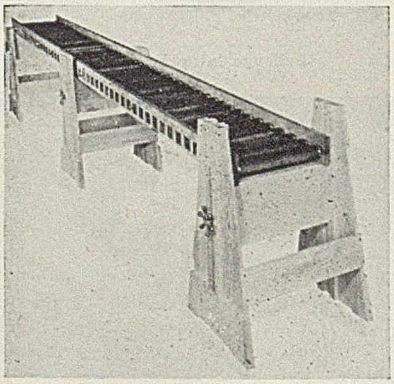
Emergency Power Unit

TO MEET THE NEED for emergency light and power protection, created by national defense activities, the Electric Storage Battery Co., 19th St. and Allegheny Ave., Philadelphia, Pa., has announced four new Exide emergency light and power units for industrial use. The units are said to be similar in principle to a large number which have been manufactured by an affiliated company in England for use in emergency lighting in bomb areas and air-raid shelters. These units are available in capacities from 3,400 to 10,000 watts, while other systems made by the company are built in sizes ranging from 240 to 100,000 watts. A unit is used in connection with an Exide battery of either the chloride or the flat plate type. An automatic transfer switch instantly transfers the battery to the emergency lighting circuit upon failure of the normal a.c. supply. As soon as a.c. service is restored, the emergency lighting circuit is instantly transferred back to the a.c. supply. Immediately upon resumption of normal power, the battery automatically is placed on high charge rate. As soon as recharging is completed, the high rate is automatically cut off and a copper oxide rectifier then supplies a trickle charge just sufficient to maintain the battery fully charged.

Can-opener-type drum opener



Wooden conveyor for explosives plants



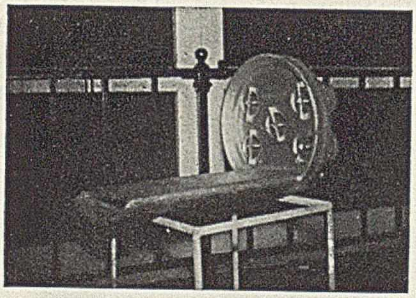
Piston-Type Bubble Tray

TO FACILITATE making up distillation columns for pilot plants, development laboratories and also small plant-scale fractionation operations, Southwestern Engineering Co., 90 West St., New York, N. Y., has developed a piston-type bubble tray which can be installed in standard pipe to make up a column of any desired height in diameters ranging from 4 to 24 in. A woven asbestos packing is used to seal the periphery of the tray against the pipe wall. The number of bubble caps used varies with the size of the tray, ranging from one for the 4-in. size, to 18 for the 24-in. size. A down-flow pipe to carry liquid to the next lower tray is formed integrally with each tray. Trays and caps are made of close-grained gray cast iron although castings of other compositions can be supplied if necessary. Standard tray spacing is 18 in. but down-flow pipes of different lengths may be supplied.

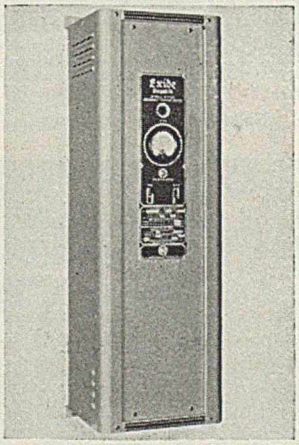
Inspection Door

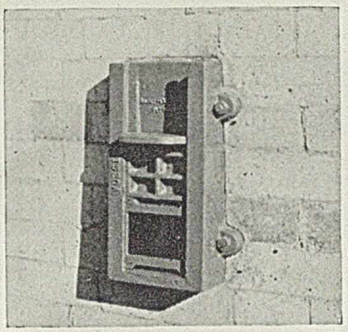
DESIGNED especially to withstand high temperatures, a new furnace inspection door has recently been developed by Gillette Kiln Sales Co., 712 Investment Bldg., Pittsburgh, Pa. This

12-in. bubble tray with five caps

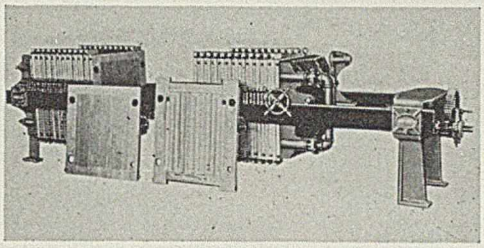


Emergency light and power unit

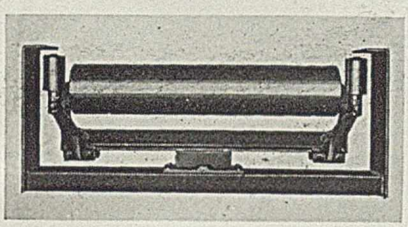




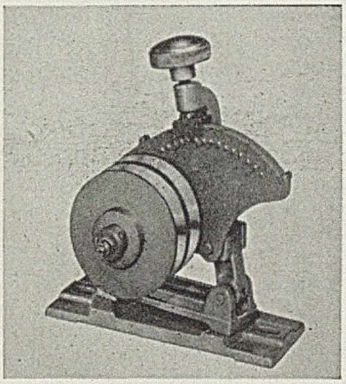
New furnace inspection door



New filter-type thickener



Self-aligning idler



JFS-Cub variable-speed transmission

new door is suitable for attachment to industrial furnaces and kilns having continuous temperatures up to 2,500 deg. F. The door consists of a cast iron slide which rides vertically in a cast iron frame assembly. When closed, the slide with its heat-dissipating fins, closes the porthole. To open, the slide is raised to bring a framed rectangular piece of Pyrex heat-resistant glass opposite the porthole. Still further raising permits inserting an instrument or tool into the furnace. The door is claimed to be easily installed on new or existing furnaces. Either blue or clear heat-resisting glass may be had.

Variable Speed Transmission

A SMALL variable speed transmission for use with V-belt drives has been announced under the name of JFS Cub by Standard Transmission Equipment Co., 416 West 8th St., Los Angeles, Calif. The unit, which is capable of a speed range of 3.3-1, is small and light in weight but capable of transmitting as much power as may be handled by an A-section V-belt (½x11/32 in.) The unit comprises a pair of variable V-pulleys, the pulley spindle being capable of movement toward or away from the motor or driven machine, thereby automatically changing the driving ratio of the variable pulleys. Any speed in the range of the machine may be selected by moving a lever along a sector and locking it in place by turning a knob.

Self-Aligning Idler

AUTOMATIC CORRECTION of misalignment of either the carrying or return run of a non-reversing conveyor belt supported on flat-roll idlers is possible with a new positive, swiveling, self-aligning idler developed by Link-Belt Co., Indianapolis, Ind. The new idler has a centrally pivoted cross member which, besides being equipped with the flat idler roll for supporting the belt, has a vertically mounted actuating roll at each end for lightly contacting the edge of the belt when its lateral misalignment exceeds a predetermined amount. But slight pressure of the belt edge against the actuating roll serves to swivel the idler unit on the pivot sufficiently to guide the belt automatically back to proper alignment. When used on return runs, one idler is placed close to the tail shaft so that the belt is guided centrally on the pulley, and another at every 10 or 15 idler spaces. On the carrying run, one idler is placed just beyond the loading chute and one every 10 or 15 spaces thereafter.

Dual Pump Drive

TO ASSURE uninterrupted water supply from deepwell turbine pumps, the Peerless Pump Co., 301 West Avenue 26, Los Angeles, Calif., has announced a dual drive which is normally powered by an electric motor head, but can instantly be switched to a source of stand-by power, such as a gas, gasoline or diesel engine, or a steam turbine. The stand-by power is connected to the unit by means of a right-angle gear, and may be brought into operation either manually or by automatic control. This company also provides dual drive pumps with steam turbines as the primary power and an internal combustion engine connected with the secondary right-angle gear.

Filter Type Thickener

WHAT IS SAID to be a totally new principle in devices for the thickening of suspended solids is the new filter-press-type thickener recently developed by T. Shriver & Co., 810 Hamilton St., Harrison, N. J. The new thickener does not depend upon settlement, but rather upon removal of a part of the liquid by filtration through a permeable filter membrane, while the solid suspension is flowing through a channel of greater or lesser length. The method is said to be particularly suitable for solids which are slow in settling, either because their density approaches that of the liquid in which they are suspended, or because they are in a finely divided state. Another advantage claimed for the new method is its extreme compactness, making it suitable for use on rapidly settleable material where the cost of special materials of construction would be too high if ordinary thickeners were used.

This machine is a modification of the company's standard plate-and-frame filter press. Many of the parts are interchangeable with those of a filter press of the same size. The frames are so designed that filter cake does not build up on the filter medium. Instead, all solids are continuously swept out of the unit in a stream of slurry which is progressively thickened. Thus a continuous stream of relatively thin slurry enters the thickener and continuous streams of clear liquid and thickened slurry are discharged. There is no need to stop the unit at any time for cleaning or removal of cake.

Employing a standard filter press skeleton, the new unit uses special types of plates and frames. Each frame contains a spiral groove which starts in one corner and spirals to the center where it passes through the frame and spirals outward on the other side of the frame to a different corner. A spiral on one side of a frame has the reverse rotation of that on the opposite side. Thickener plates contain spiral ribs which match the ribs between the grooves of the frame. A slightly different construction used for wood frames has vertical wood baffles on both sides with vertical channels feeding from one side of the frame to the other. Wood plates are grooved similarly to ordinary wood filter plates.

In operation the slurry to be thickened is pumped into the unit, reaching the channels of the frame first. From the channels a portion of the liquid passes through the filter medium, issuing as clear liquid which drains away on the plates and thence from the unit. All suspended solids in the original feed remain in the slurry stream in the frames and are continuously discharged from the unit. Slurry velocity through the frames prevents building up any cake. In batch thickening, the thickened slurry returns to the supply tank and is circulated until the desired thickness is obtained. In batch washing, material is recirculated to the desired thickness and then fresh water is added to the supply tank at a rate equal to the effluent discharge until the material is adequately washed. The unit is also adaptable to continuous or intermittent countercurrent washing and leaching. Multiple thickeners, tanks and pumps are employed for such operations. In a number of such applications already made, remarkable decreases in processing time compared with thickening by settlement are claimed by the manufacturer.

Improved Controller

Model 30 is the type number given to the latest design of Stabilog controller introduced by the Foxboro Co., Foxboro, Mass. Changes in the new instrument consist principally in refinements, since it has not been found necessary to alter fundamental principles of operation. The new Model 30 employs the company's recently designed universal rectangular case which, when panel mounted, extends only ¾ in. from the panel surface. All operating adjustments can be made from the front of the case, the adjusting mechanisms for change of control point, throttling range and reset resistance being immediately accessible when the door is opened. The operating mechanism, however, is protected and concealed behind a removable plate. Unit construction simplifies any necessary replacement of the measuring system, or change in the type of control. The controller incorporates three principal functions: the first is proportional pneumatic control, which is adjusted to the smallest value that will result in stabilization following a disturbance of process conditions. The second is the reset function, acting simultaneously with the first, to establish stabilization at the desired point of control. The third function provides a temporary additional correction which is large if the rate of change of the process variable is fast, or negligible if it is small.

Equipment Briefs

A new photo-electric colorimeter, known as the AC Electrophotometer, has recently been announced by Fisher Scientific Co., Pittsburgh, Pa. This model, which operates on alternating current, incorporates a compensating means capable of handling all ordinary fluctuations in line voltage. The unit is compact, completely self-contained and designed for simplified operation. It employs four different illumination intensities and can use three different types of absorption cell to cover a wide range of solution volumes.

For applications on industrial equipment, where the blind mounting of nuts is necessary, Elastic Stop Nut Corp., 2332 Vauxhall Road, Union, N. J., has announced a special anchor type vibration-proof nut which may be permanently riveted to the inside of the structure. Each nut incorporates this company's self-locking feature, consisting of a fiber locking collar which is an integral part of the nut and prevents the bolt from becoming loose after it has been installed in the nut, regardless of the severity of vibration to which it is subjected.

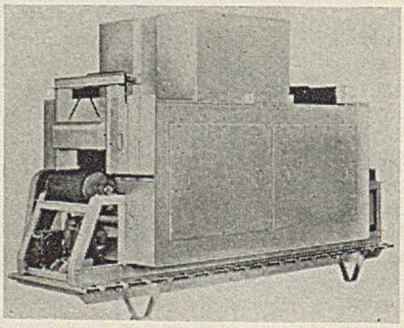
Downingtown Iron Works, Downingtown, Pa., has recently set up a separate division for the design and manufacture of heat transfer equipment. The new heat transfer division, which is being housed in its own building, will design and build steel and alloy heat exchangers for various process heat transfer applications, including heaters, coolers, condensers, hot water heaters, brine coolers and refrigeration exchangers.

In a recent announcement, American Cyanamid Co., 30 Rockefeller Plaza, New York, N. Y., has announced expansion of its activities to cover technical service on heavy-media (sink-and-float) separation processes. Processes include those for both non-ferrous and ferrous minerals.

U. S. Bureau of Mines approval has been accorded to the new Dustfoe single-filter respirator for dusts and mists recently announced by Mine Safety Appliances Co., Braddock, Thomas and Meade Sts., Pittsburgh, Pa. The new filter element is all in one piece, replacing the two-part (felt screen and cellulose) filters used previously. The filter is more porous on the outer side so that larger dust particles are filtered out first, thus preventing rapid build-up of breathing resistance through clogging of the filter. The unit is light in weight and compact, offering low breathing resistance and full vision in every direction. A protective filter cover helps to prevent contamination of the filter by grease and dirt.

A new line of drum controllers for small cranes and hoists, having several new features, has been announced by Cutler-Hammer, Inc., 315 North 12th St., Milwaukee, Wis. A rope-operating lever, employing a new equalized-torque principle, eliminates the sheave wheel, rope guard and external return spring, providing smooth, easy operation when the rope is pulled at an angle. A new anti-plugging feature increases the drum life by making it impossible to whip the drum from the full forward to full reverse position. The drum can be reversed quickly, but yet a definite time delay is required in the off position.

New conveyor oven



Addition of a series of paint and lacquer spray hoses in inside diameters from ¼ to ½ in. has now given the B. F. Goodrich Co., Akron, Ohio, a complete line of synthetic rubber-lined hose from ¼ in. to 10 in. inside diameter. The company's product, Ameripol, is the synthetic rubber used. The new paint-spray hose uses a black oil-resisting compound, designed for 150-lb. working pressure in all sizes.

National-Erie Corp., Erie, Pa., has announced new large-capacity continuous extruding machines for the insulation of wire and cable with thermoplastic compounds. The new units are available with plasticizing cylinders from 3½ to 12 in. in diameter, the cylinders being completely jacketed for high temperature operation. Improved axial extruding heads suitable for tubes or straight extruding of miscellaneous commercial shapes are standard equipment. A variety of head constructions are available for insulating service.

Conveyor Oven

Designed for heating, drying and heat-treating in the temperature range up to 1,250 deg. F., a new conveyor-type convection heated furnace has been announced by The Gehnrich Corp., Long Island City, N. Y. When desired, preheating and cooling sections can readily be added to the heat processing chamber. The furnace is constructed of alloy steel, eliminating the need for refractory lining. The walls are of patented insulated panels, packed with mineral wool blankets. Through metal joints are eliminated, thus reducing heat losses and providing for ready expansion and contraction of the walls and for easy assembly, enlargement or relocation. Heat is provided by electric heating elements and transferred to the ware by means of air moved by a large-capacity fan located above the oven which draws air from the heaters and discharges it over the full length and width of the oven. The hot air then recirculates to the heater. An external gas- or oil-fired heater can also be used if desired. The conveyor consists of a wire-mesh belt running over steel drums at both ends of the oven and driven by a motorized variable-speed drive.

MORE THAN 2 YEARS ON THE JOB — NO TROUBLE

"'1000' valves have regulated perfectly since they were installed over two years ago. We have never opened them up." —Case No. 177

Three Years Remarkable Service

"The first Streamlined Valves we bought from you have been in about three years—we have had no trouble whatsoever. This service is remarkable." —Case No. 179

4 YEARS ON THE LINE

"Our first '1000' valve has never been out of the line in four years. We adjust it constantly for different pressures and it stays put." —Case No. 135

4 YEARS SERVICE AND STILL GOING

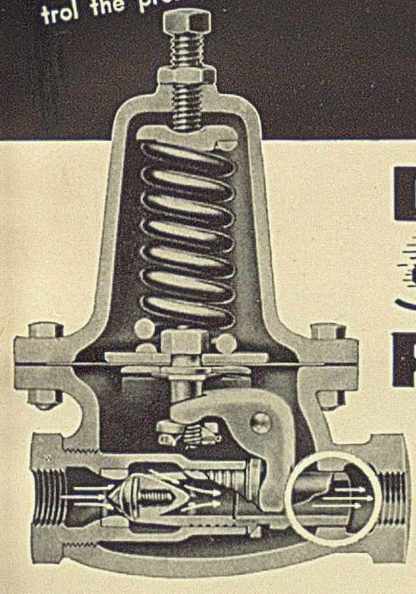
"We have dozens of these Streamline Regulators in use, yet over a four-year period we have not spent one dime for repair parts." —Case No. 143

After 18 months . . . seat and ring show no wear . . .

"As far as maintenance is concerned, we put them in and forget about them — they really control the pressure." —Case No. 309

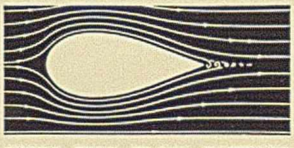
5 YEARS WITHOUT SERVICE ATTENTION

"We had to have capacity and close regulation—we got all that and more — this valve has given excellent service—no repairs needed in five years." —Case No. 325



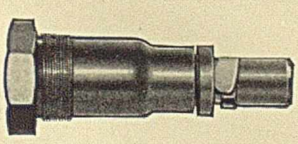
CASH STANDARD *Streamlined* TYPE 1000 PRESSURE REDUCING VALVE

• The Aspirator (circled in "1000" illustration above) gets the inner valve wide open to meet the demand and hold delivery pressure constant.



GIVES THIS FLOW PATTERN The Streamlined form of the inner valve eliminates turbulence. It produces the flow pattern shown above which makes for maximum capacity when it is needed most, and permits accurate pressure control under toughest working conditions.

★ Accurate, reliable pressure reduction service for steam, air, oil—most anything that flows — at definite cost savings. That is what you can expect from a CASH STANDARD Streamlined Reducing Valve. In addition you have the following points that you can definitely figure on — smooth operation — elimination of failures and spoilage — speedier production — and an end to worry and bother. Years of service in a wide variety of installations show that users of the "1000" valve do get all of these benefits. Sizes ¼" to 2" screwed ends.



• Straight path for the fluid through the flow tube—gives you better pressure control and greater capacity.

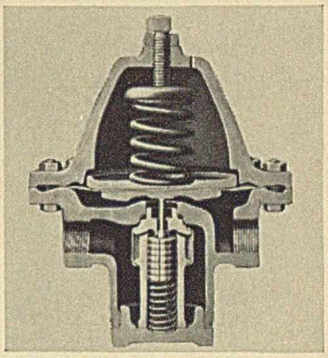
• Streamlined flow around the inner valve—eliminates turbulence—thereby gives you best control under varying loads.

• *Send for Bulletin 1000—it gives you the complete story.*

A CASH STANDARD "GET ACQUAINTED" COLUMN

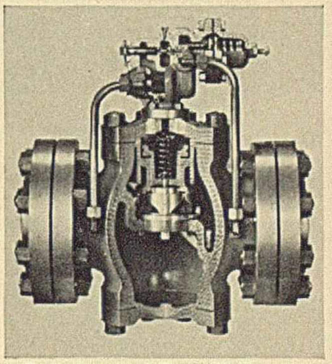
Question: "Don't you people make anything besides that Streamlined Valve you talk about so much?"

Answer: "Yes Sir; we do! And we propose to picture one or two of them here each time."



Cash Standard Class D Pressure Reducing Valve; inexpensive; dependable. Used in regulating steam, hot water, cold water, air, oils, many chemicals and most gases. Sizes ¼" to 2"; screwed ends.

Initial pressures up to 250 lbs., reduced pressures up to 200 lbs. Bodies in iron, bronze or steel. Trim; iron, bronze, stainless steel, monel metal, or nitralloy.



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

Sizes: 2" to 12". Initial pressures up to 600 lbs.; highest reduced pressure 250 lbs. For water, air, Freon, ammonia, any non-corrosive gas or oil. Valve operating fluid not wasted: it discharges to outlet pipe.

Bodies: iron, bronze, steel. Trims: iron, bronze, stainless steel, or monel metal. Ends: screwed, flanged, or ammonia type.

Get Free Bulletins on Above . . . Write to A. W. CASH COMPANY DECATUR, ILL.

A. W. CASH COMPANY
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CASH STANDARD CONTROLS.. VALVES

Plate Glass Manufacture

THE CREIGHTON (Pa.) plant of the Pittsburgh Plate Glass Co. has the distinction of being first in several respects. It is the No. 1 works of the company, and one of the first plants to manufacture by continuous process. The first glass was produced in this plant in 1883, and it has been in almost continuous production since that time. For many years it has been producing 7/64 in. polished plate for use in the manufacture of laminated safety glass.

Raw materials for the production of glass consist of sand, soda ash, salt cake, limestone and cullet. The batch is weighted, mixed and elevated and conveyed to hoppers. From here the material is fed into the melting end of the furnace which has a capacity of 1,400 tons of glass. Molten glass leaves the refining end between rolls. The glass ribbon is annealed in a gas-fired lehr 400 ft. in length. While the glass is cooling the edges are trimmed, inspected and cross cut. At this point the rough plate is raised and lowered by means of vacuum cups. It goes either to storage racks or to the grinding and polishing line.

On the grinding and polishing table the plate is embedded in plaster to hold it firm. Thirty grinder runners, using sand, give a smooth finish on one side and 60 runners polish the glass. It is then stripped from the tables, turned over with the polished side down and embedded in new plaster. The grinding and polishing operations are repeated on the second side of the plate. It is lifted and placed on the washing conveyor. After a thorough washing to remove dirt the glass is inspected, cut to the desired final size and packed for shipment.

Shipment of the plate glass is done either in box cars or on flat railroad cars. Automobile glass is packed in boxes and large glass is shipped in gondolas.

The accompanying pictures illustrate the essential steps in the process used at the Creighton plant of Pittsburgh Plate Glass Co.

CHEMICAL & METALLURGICAL ENGINEERING

January, 1942

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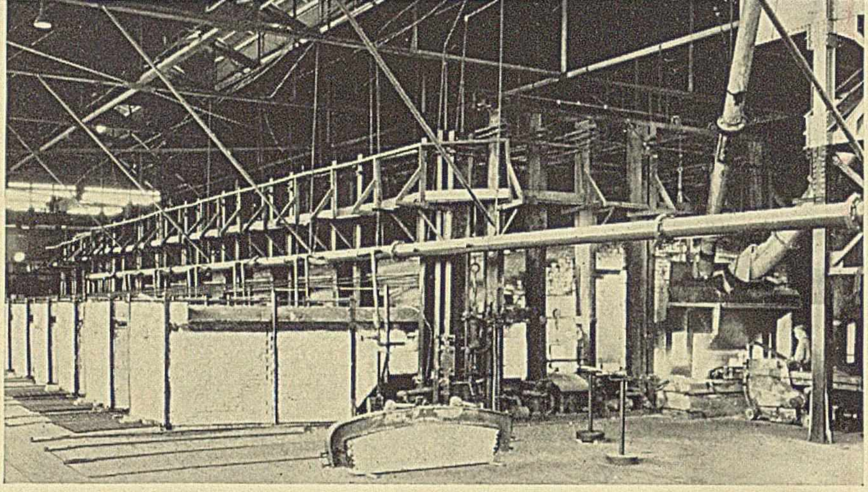
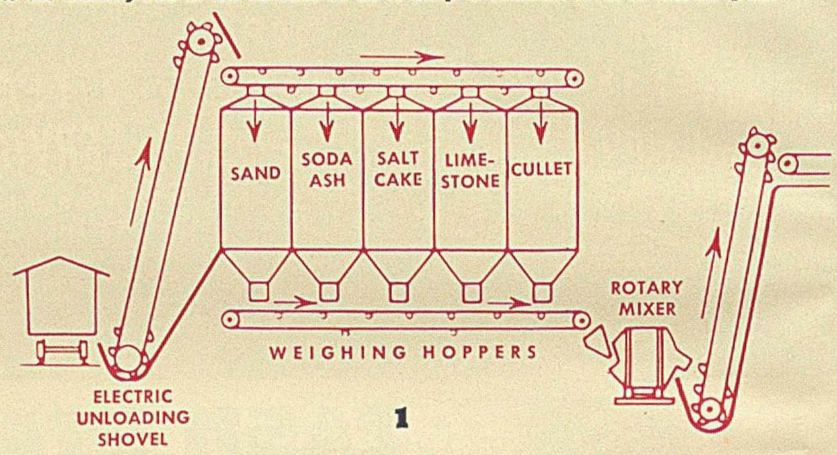
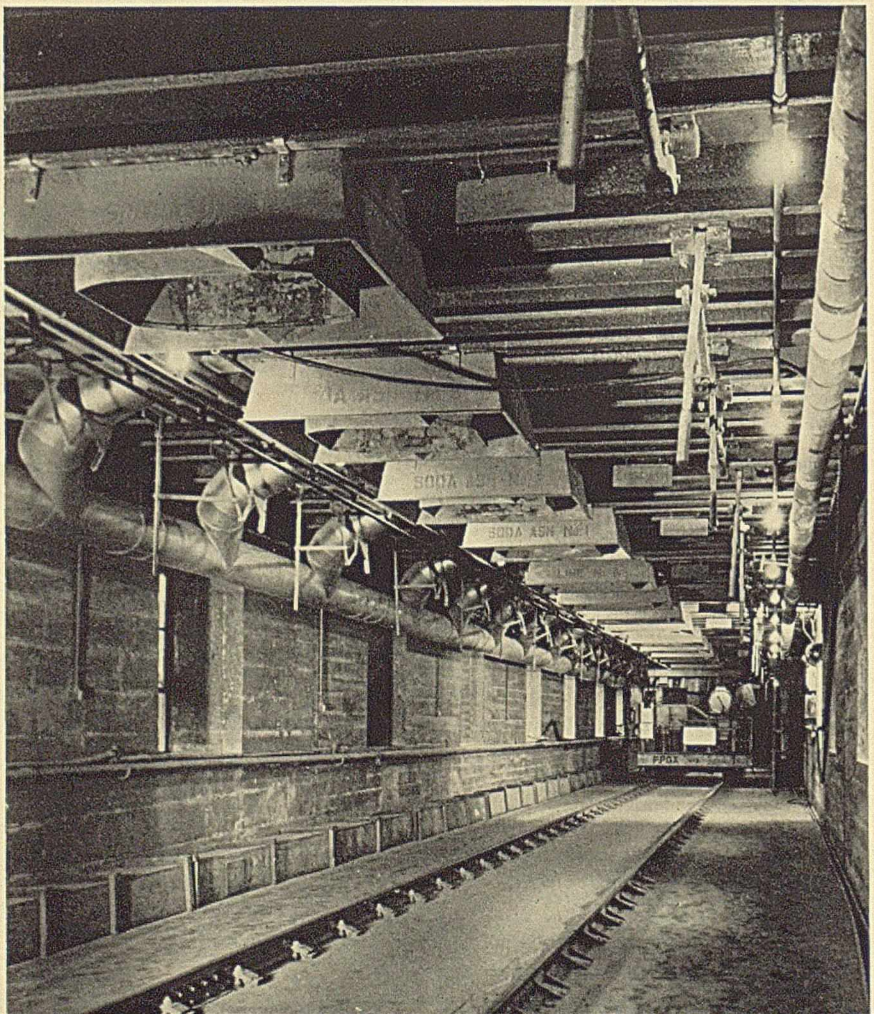


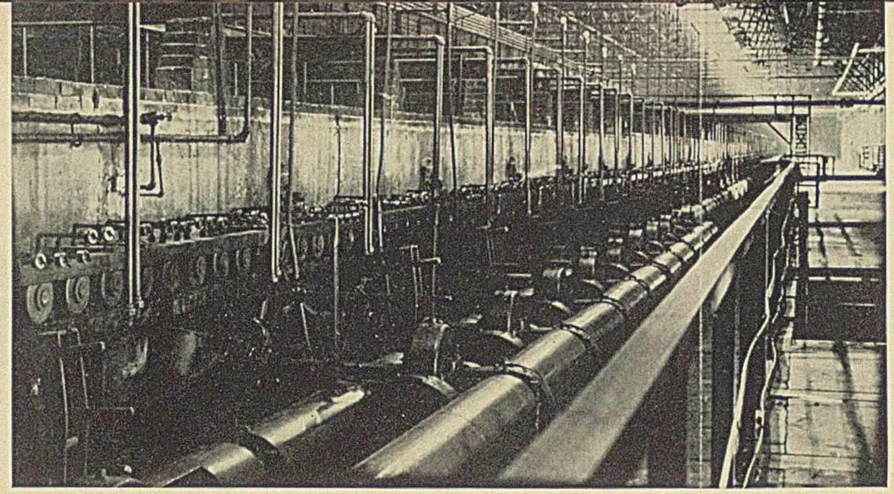
2 After mixing raw materials are conveyed to the batch hopper and then fed into the melting end of the furnace so as to keep a constant level of molten glass



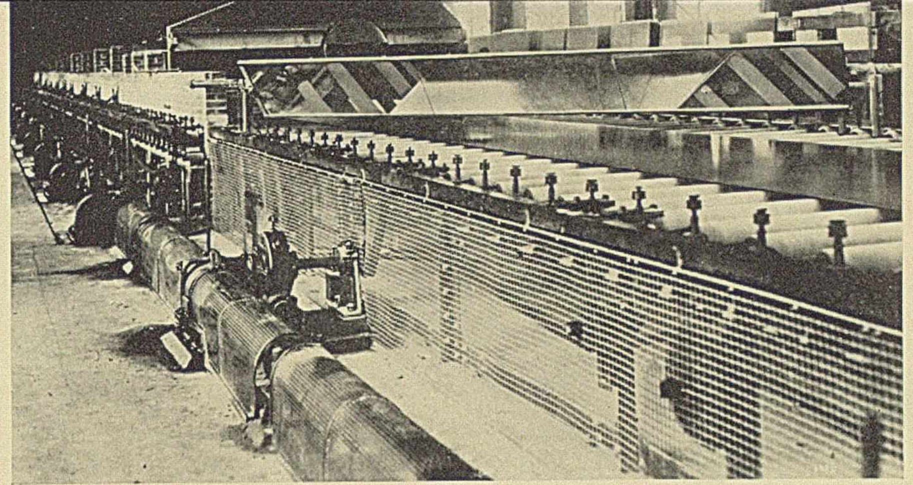
1 Raw materials, sand, soda ash, salt cake, limestone and cullet, are weighed at these hoppers before being carried by conveyor to the mixer



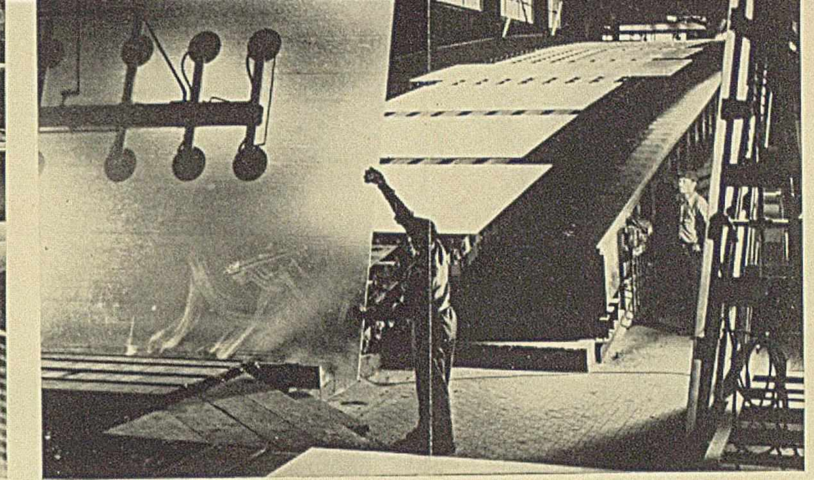
3 The melting tank has a capacity of 1,400 tons. The molten glass pours through the tank throat between rolls in the form of a ribbon



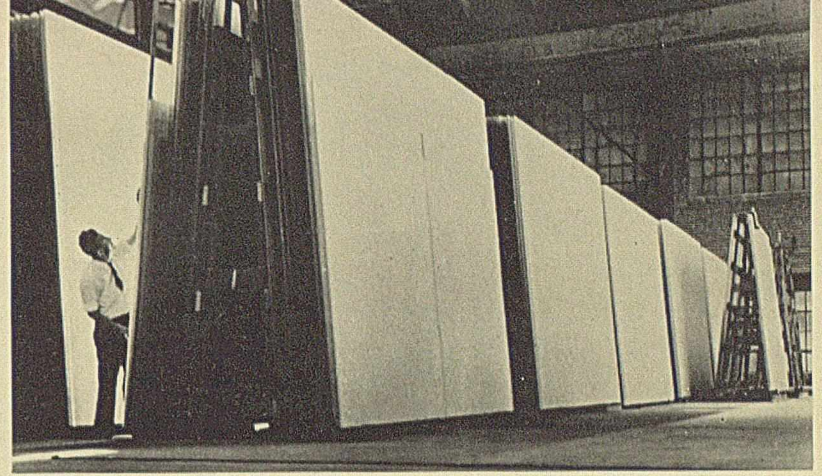
4 The glass ribbon is annealed in a gas-fired lehr 400 ft. long. Temperatures of the lehr are regulated at many points along the entire length of the tunnel



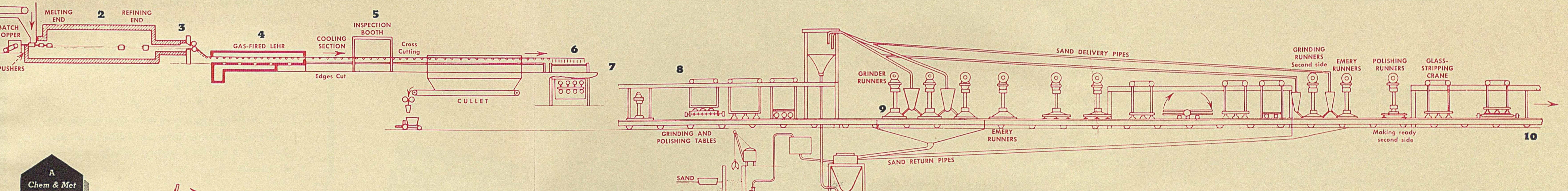
5 The ribbon is cooled and every square inch of it is given a careful visual inspection while passing through the inspection booth on the line

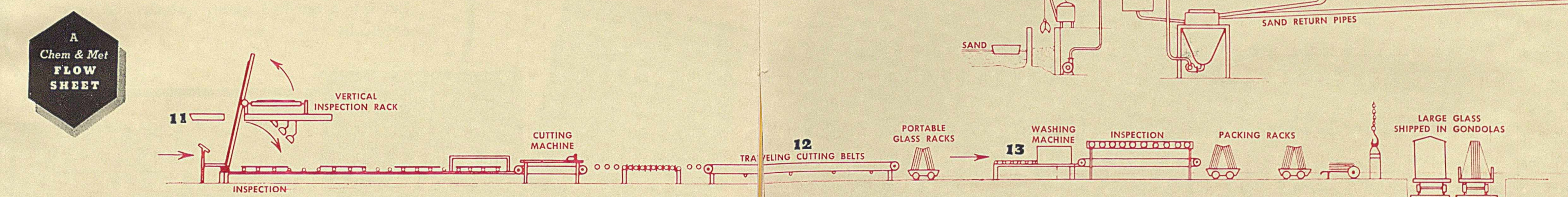


6 After inspection the ribbon is cross cut and separated into plates. Cullet falls into a hopper, is crushed, and conveyed back to batch



7 At this point the rough plate is raised and lowered by vacuum cups. It goes either to storage racks, as shown, or to the grinding and polishing line





12 Marked sheets or plates pass along the line to the cutting machine where they are cut into the sizes required by the customer

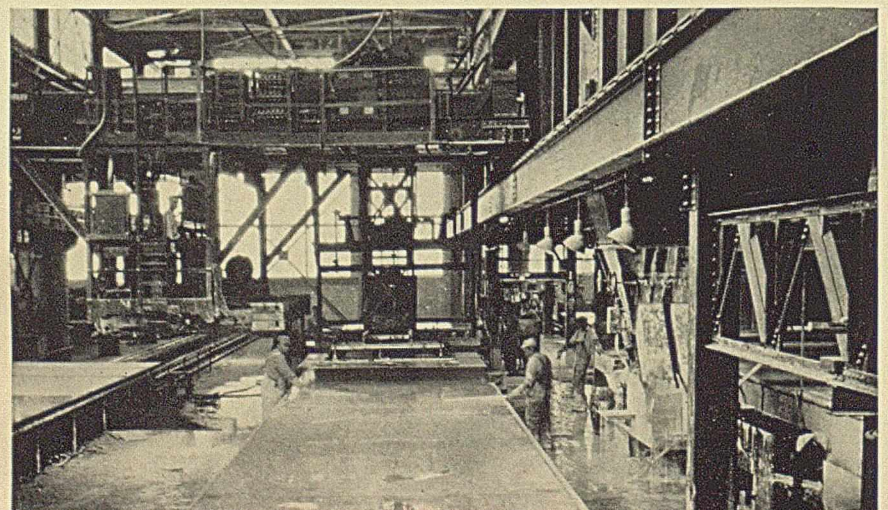
13 Portable glass racks convey the product to a washing machine. The glass is given another inspection and is packed for shipment

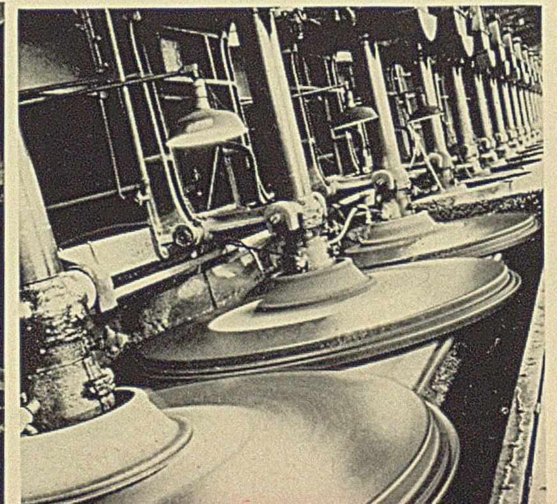
8 Beginning of the grinding and polishing line or table. Plaster is spread on the table and the glass embedded in order to hold it in position

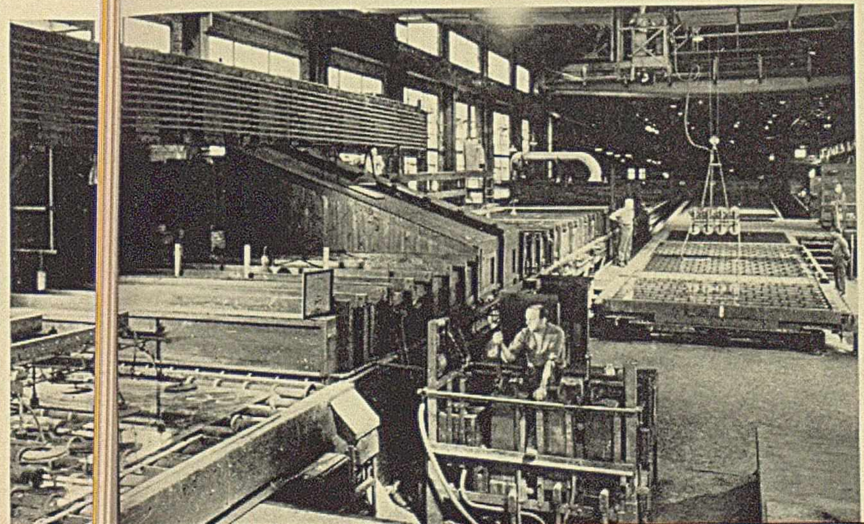
9 About 30 grinder runners are used. Several emery runners give final smooth finish

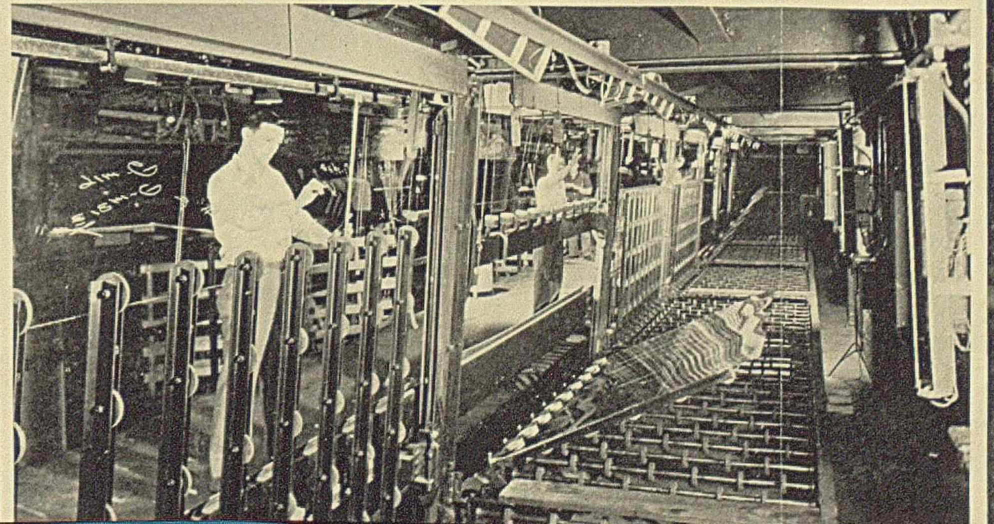
10 One side of the plate having been polished is stripped from the table, turned over, and the grinding and polishing operations are repeated.

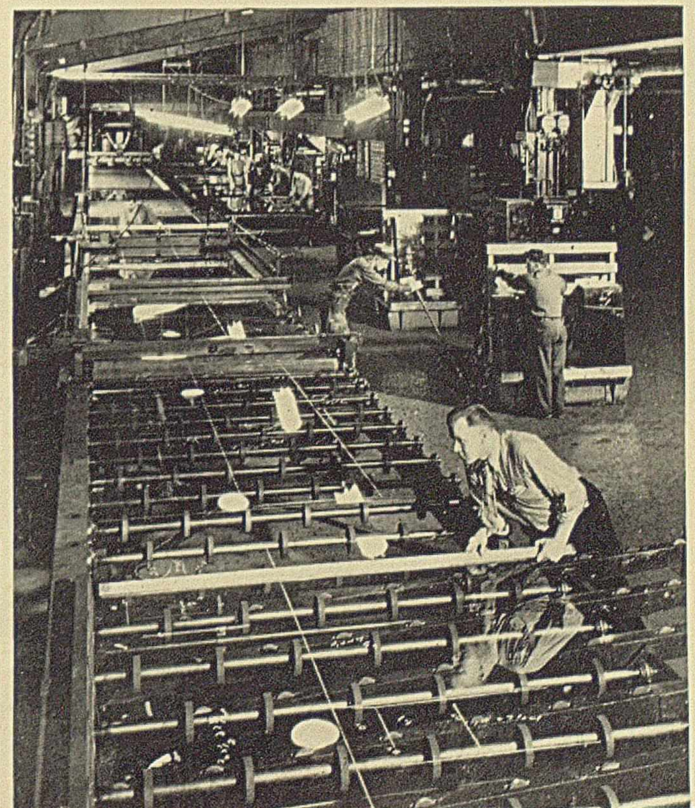
11 The washed glass plate is placed in a vertical inspection rack, where it is marked for cutters. The plate is then inspected for defects and lowered to the conveyor

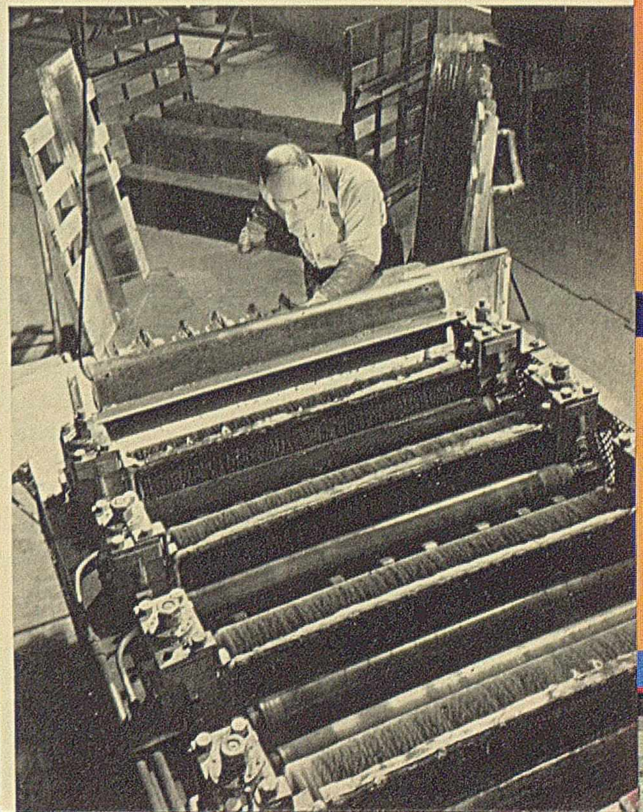












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