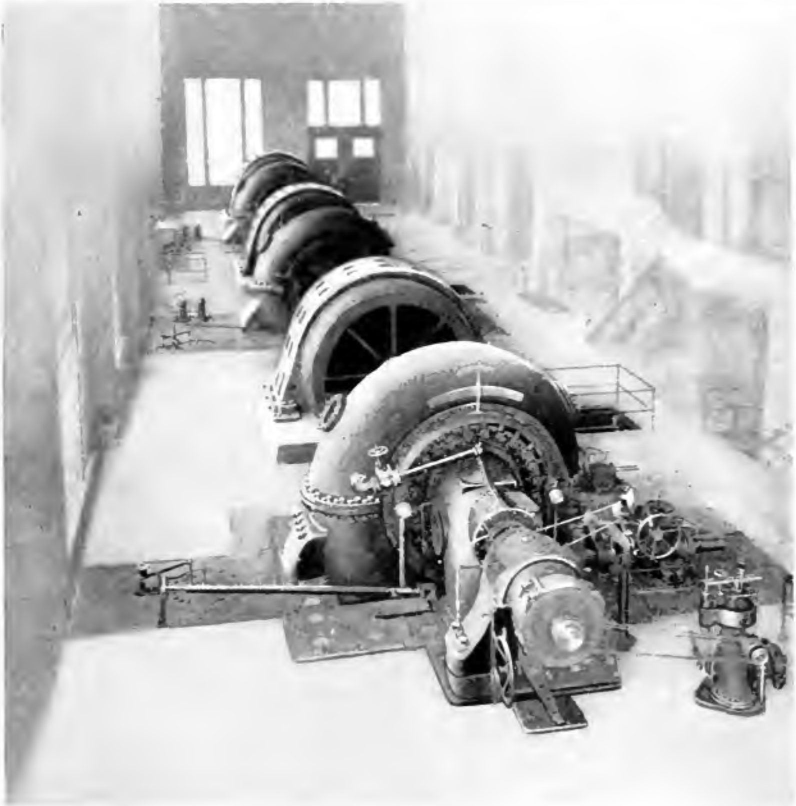
TWO DOLLARS PER YEAR TWENTY CENTS PER COPY

GENERAL ELECTRIC REVIEW

VOL. XXII, No. 1

Published by General Electric Company's Publication Bureau Schenectady, New York

JANUARY 1919



The 20,000-kv-a. hydroelectric generating set in the foreground of the above illustration (White River Development, Puget Sound Traction, Light and Power Company, Seattle, Wash.), and the 32,500-kv-a. generator on page 11, constitute two of the landmarks of the year 1918. The former was the largest capacity waterwheel-driven generator at the time of its installation, and the latter the largest under construction.

THE

GENERAL ELECTRIC REVIEW

VOLUME XXII

1919

PUBLISHED BY
GENERAL ELECTRIC COMPANY
SCHENECTADY, N. Y.

"NORMA"
PRECISION BEARINGS
(PATENTED)

For
Fractional H.P. Motors

National conservation, rightly understood, contemplates the manufacture, sale, and use of machinery and equipment possessing within itself the maximum of "staying power." Repairs and replacements on old equipment may be an economical virtue. But a truer conception of economy demands the making of machines so good that repairs and replacements are minimized.

Builders of high-grade, high-speed, high-duty machines, seeking to incorporate in their designs the utmost of time-resisting, wear-resisting quality, fortify their own superior construction with the recognized serviceability of "NORMA" Precision Bearings.

Be SAFE
See that your Motors are
"NORMA" *Equipped*

THE NORMA COMPANY OF AMERICA
1790 BROADWAY NEW YORK

Ball, Roller, Thrust, and Combination Bearings

"NORMA" *Engineers—speed bearing specialists—offer you their services without obligation*

General Electric Review

A MONTHLY MAGAZINE FOR ENGINEERS

Manager, M. P. RICE   Associate Editors, B. M. EOFF and E. C. SANDERS   [illegible]

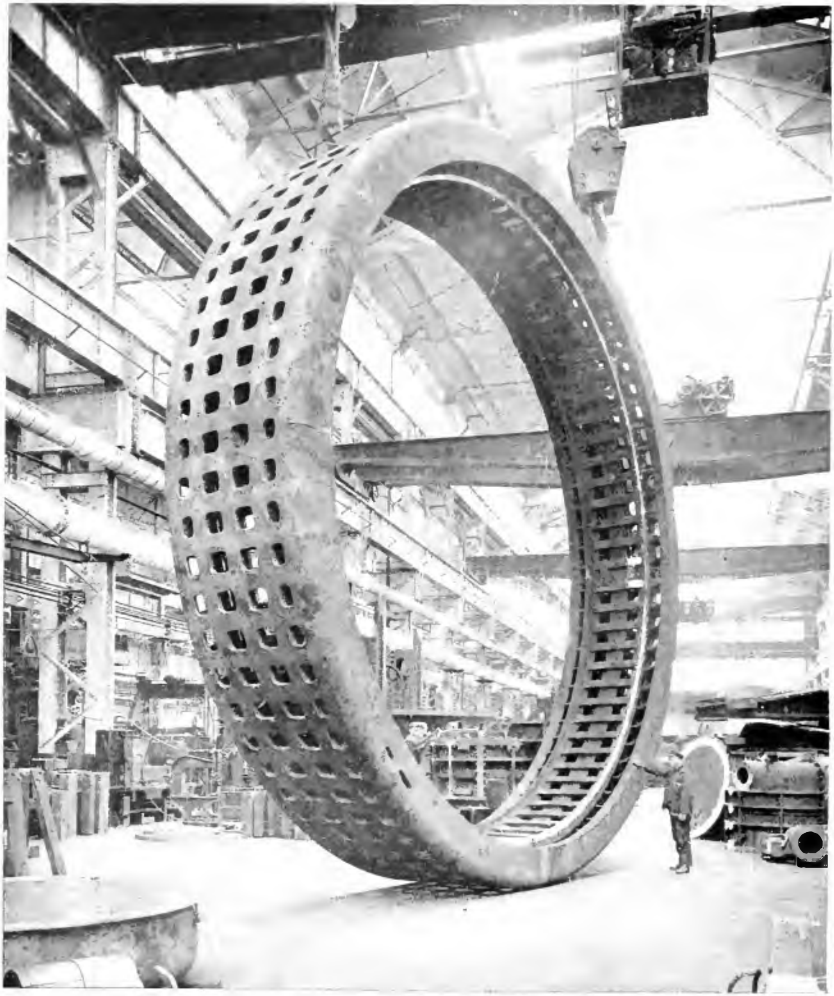
Subscription Rates: United States and Mexico, $2.00 per year; Canada, $2.25 per year; Foreign, $2.50 per year, payable in advance. ***Library and Student Rates:*** United States and Mexico, $1.50 per year; Canada, $1.75 per year; Foreign, $2.00 per year, payable in advance.

Remit by post-office or express money orders, bank checks, or drafts, made payable to the *General Electric Review*, Schenectady, N. Y.

Entered as second-class matter, March 26, 1912, at the post office at Schenectady, N. Y., under the Act of March, 1879.

Vol. XXII, No. 1 January, 1919

CONTENTS



While the general trend in electric generator design is toward increased capacity with decreased size and weight, there occasionally are certain conditions, such as low speed, which require a departure from this practice. The capability of the industry along the latter line is typified by this impressive illustration of a 31-ft. (outside diameter), 72-ton (as shown) armature spider of one of the fifteen 52-pole, 9000-kv-a., 57.7-r.p.m., 25-cycle, 11,000-volt waterwheel-driven generators now in operation at the Keokuk Station of the Mississippi River Power Company.

GENERAL ELECTRIC REVIEW

Reconstruction Congress of the War Service Committees of American Industry

What greater assurance of a business-like transition from war activities to peace activities could we have than that, through our recent training in war, all our citizens individually and collectively have acquired the ability to distinguish clearly between the essential and the non-essential, to decide quickly upon a singleness of purpose, and to proceed with remarkable speed and team work! Ample proof of the efficacy of these faculties when directed toward the adjustment of the nation's activities to peace-time conditions was furnished, within four weeks after Germany signed the Allied terms of armistice, by the convening of over 4000 representatives of American industry at a Reconstruction Congress held under the auspices of the Chamber of Commerce of the United States and there in four days shaping and laying the foundation stones of our coming business era.

The program of the Congress introduced pertinent questions and called for their discussion by the 380 War Service Committees representing American Industry, the consideration of these recommendations by 35 related groups, the summarizing of the conclusions by ten major groups, and the framing of a set of resolutions by a Clearance Committee* to represent, in so far as possible, the prevailing opinion of all the minor meetings. The stupendous task was scheduled to be carried out December 3rd to 6th inclusive and to be paralleled by general session meetings of the Congress at the Million Dollar Pier, Atlantic City.

The general sessions were addressed by the president of the Chamber of Commerce of the United States, who emphasized the importance of the part that business men must play in the reconstruction of our disordered world, and by speakers who are national leaders of our industrial progress. These men made it remarkably clear that we now stand on the threshold of a new era and that, as the late President McKinley predicted, our period of national exclusiveness is past.

Paul Warburg, former member of the Federal Reserve Board, expressed the belief that the time is near when "American dollar acceptances will be outstanding to the extent of more than one billion dollars in credits granted all over the globe." The stimulus that will be given American trade by this expansion to four times the present acceptances of New York or twice those of London, is apparent. However, it is not a matter of displacing London as the world's banker, but rather of entering into partnership in trade big enough to divide, even admitting other partners to share the place which Germany has vacated for an indefinite future.

Also, Mr. John H. Fahey warned us against entering upon our foreign trade expansion with an aggressive spirit.

"If we pursue a grab-it-all policy, we shall turn good will into ill will which will last for years. And what nation, pray, is going to grab trade from us if we do not grab it first? Half a continent must be rebuilt. Where are the rebuilding nations to get what they need except from the United States? If we do not attempt to grab all, we shall continue to hold the nation's friends we have and shall have prosperity in the near years greater than we have ever known."

* Personnel of the Clearance Committee and the major groups represented: Judge Joseph H. Defrees, Chicago, chairman; E. W. Rice, Jr., New York, heat, light and power; Lewis E. Pierson, New York, food; John W. O'Leary, Chicago, iron and steel; Eugene Meyer, Jr., New York, metals aside from iron and steel; Charles Cheney, Manchester, Conn., textiles; John H. Kirby, Houston, Texas, wood; Dr. William H. Nichols, New York, chemicals; August H. Vogel, Milwaukee, leather; N. E. Carson, Riverton, Va., earthern products; Charles A. Stone, New York, industrial professions; R. G. Rhett, Charleston, S. C., Charles Nagel, St. Louis, C. S. Brantingham, Rockford, Ill., members at large.

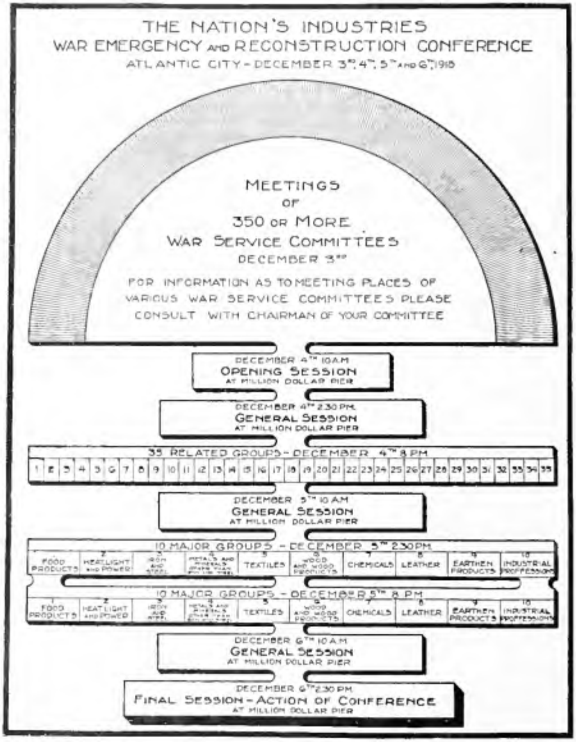
With respect to the proposition to place a boycott on trading with our late enemies, Mr. James Farrell said:

"In the presence of the gigantic needs of the war-swept territories in Europe and of their poverty-stricken population, any application of the old-time methods of competition must sound trivial. Co-operation on a large and magnanimous scale and in the most sympathetic spirit must be the rule if the economic recovery is to be quick and thorough. Moreover, we shall greatly lessen the possibility of perpetuating in the domain of commerce the hatred and bitterness engendered by the war if we refuse to be drawn into any convention, agreement, or understanding that would make us parties to a boycott of the commerce of any of the nations that have been arraigned against each other."

Continuing on the same subject Mr. Farrell stated:

"It is certain that if Germany is to be compelled, as she ought to be, to repair the wanton destruction she has wrought in Belgium, Northern France, Poland, and Serbia, she must have access to the raw materials of manufacture, in the conversion of which into finished products she may earn the money needed to pay her debts.

"As a matter of fact, given the frank acceptance by Germany of the terms of peace which will be dictated by the Allies, there can be no reason for separating her economic wants from those of the rest of Europe. These will be sufficiently imperative to use up all the surplus foodstuffs and raw materials that can be spared for many months to come."



It is interesting to note that we are well prepared to export many of the commodities we formerly imported. Some 427 staple products formerly imported, we now make; before the war we imported $7,000,000 worth of dye stuffs annually and we are now exporting $10,000,000 a year.

To make a big export trade possible, ships are necessary. Charles M. Schwab made an earnest plea that our merchant marine activities be continued unabated, and justification for this recommendation was voiced by Secretary of Commerce Redfield:

> "Every ship the world has and can get has all of its carrying capacities taken for the next two years to come. Many of our ships will be used for our growing and developing trade with South America, because a number of our vessels are of a type which it is not economical to send abroad."

Mr. Farrell said that a huge marine fleet will open to the United States a new era of commercial and industrial development and that "nothing but the shortsightedness of self-seeking politicians and the misplaced activities of injurious friends of labor can prevent this nation from becoming once more the foremost seafaring people of the world."

John D. Rockefeller, Jr., proposed an industrial creed which was heartily approved by the Convention and recommended for adoption by the four components of industry—capital, management, labor, and the community. The first and last of the ten articles composing the creed are as follows:

> (1) I believe that labor and capital are partners, not enemies; that their interests are common interests, not opposed, and that neither can attain the fullest measure of prosperity at the expense of the other, but only in association with the other.
>
> (10) I believe that that man renders the greatest social service who helps to afford the largest number of men the greatest opportunity for self-development and the enjoyment by every man of those benefits which his own work adds to the wealth of civilization.

The following brief and pleasing forecast of our national status after the present transition period was made by Mr. Warburg:

> "As I look through the telescope into the period following that of transition I see a United States to which the world at large will be heavily indebted, and to which annually hundreds of millions of dollars will be due as interest on loans extended, in addition to the hundreds of millions due in payment of the raw materials we shall be able to spare for other countries. I see an industrially highly developed country, which, with the exception of a limited number of articles, will be capable of producing most of the necessities of life for the consumption of its own people. I perceive, therefore, a country amply protected by a vast annual international credit balance, a country which by keeping some portion of its foreign security holdings in the form of reasonably short obligations should be able to protect itself against any serious encroachment upon this creditor position; a country owning a high gold stock; a country, in short, which need not give itself any great concern with regard to its power to maintain the parity of the dollar exchange all over the world."

In order that these conditions may be brought about, however, "not relaxation [illegible] must be given to the following [illegible] function[illegible] as expressed by Mr. Warburg in his address:

> "I believe we cannot emphasize too strongly that the time has not yet come when our people, large or small, may relax their efforts to curtail unnecessary consumption, both for the sake of saving for export the greatest possible quantities of food, thereby stimulating our export industries, and for the purpose of accumulating funds available for investment. The slogan 'Don't stop saving food,' would gain in scope and strength by abbreviating it into 'Don't stop saving.' Our more than 21,000,000 Liberty Bond holders must be trained to become permanent investors; thrift must become a national virtue, a priceless inheritance left to us by the war."

At the final session, December 6th, the Congress received and accepted the report of the Clearance Committee on Resolutions. The section of the report which aroused the greatest enthusiasm was one which authorized the president of the Chamber of Commerce, after consultation with representatives of other appropriate bodies, to appoint a commission of American business men to go to Europe without delay to study at first hand the reconstruction needs of Europe and to be available to the peace delegates of the United States for any needed business information.

The other resolutions adopted by the Congress, and of particular interest to the readers of this magazine, follow:

Cancellation of War Contracts. It is in the public interest that all war orders placed by any contracting agency of the government and accepted in good faith, whether formally and regularly executed or not, should, upon cancellation by such contracting agency, be promptly and equitably adjusted and satisfied as if every formality had been observed, and when so adjusted the amount ascertained to be due by the government should be promptly paid to the end that these funds may be utilized by the industries of the country to speed their transition from a war to a peace basis.

If it should be ascertained that legislation is necessary or desirable to accomplish this end, Congress should forthwith enact such legislation.

Officials dealing with questions of adjustment on account of war orders must necessarily be familiar with all the conditions affecting the order. It will greatly promote expedition and the interests of both the government and private enterprise for the officials who made the contracts to remain in the government service to participate in the readjustments.

Surplus Government Supplies. Under date of November 29th, the Secretary of War issued a public statement: "To prevent too violent dislocation of industry from the standpoint of both employee and employer, accumulation by the War Department of either raw material or finished product will be distributed when and where liquidation of such supplies will least interfere with the return of industry to normal condition." Such action would seem to insure the stability of the industries affected which fully appreciate this liberal position.

Therefore the War Service Committees of American Industries hereby tender to the War Department their services for their respective industries for the purpose of advising with and assisting the War Department in the disposition of such materials.

Removal of Restrictions of Industry. It is in the public interest that all war regulations of industry should be revoked and all war restrictions on industry should be removed as speedily as practicable, save such industries as are engaged in the production, preparation, or distribution of foods, feeds, and fuel and such last-named group of industries should be freed from war regulations and restrictions as early as consistent with the welfare of this nation and of the Allies.

Industrial Co-operation. The war has demonstrated that through industrial co-operation great economies may be achieved, waste eliminated, and efficiency increased. The nation should not forget, but rather should capitalize these lessons by adapting effective war practices to peace conditions through permitting reasonable co-operation between units of industry under appropriate Federal supervision. It is in the public interest that reasonable trade agreements should be entered into, but the failure of the government to either clearly define the dividing line between those agreements which are, and those which are not, in unreasonable restraint of commerce, or to provide an agency to speak for it on application of those proposing to enter into such agreement in effect restricts wholesome co-operation and deprives both industry and the general public of its benefits. The conditions incident to the period of readjustment renders it imperative that all obstacles to reasonable co-operation be immediately removed through appropriate legislation.

Public Works. The development of public works of every sort, as recommended by the President, should promptly be resumed, in order that opportunities of employment may be created for unskilled labor.

Inventories. We urge that Congress should give careful consideration to the grave menace now facing all industry due to the fact that both raw materials and finished goods are carried in full measure to meet the extraordinary requirements of the government and of the people, and that in large part the stocks have been acquired at abnormal cost and are therefore carried into inventories at inflated values, thereby showing apparent profits which have not been realized, and which probably will never be fully realized. These are largely bookkeeping or "paper" profits, and should not be used as a basis for taxation.

We therefore recommend that any tax law shall provide that during present conditions the taxpayer shall be allowed to make a deduction from his apparent profit by way of a reserve for a subsequent shrinkage in the value of merchandise.

We believe that the interests of the government can be protected against abuse of this privilege by the fixing of a maximum percentage of deduction to be allowed, and by the use of proper methods of inspection and appraisal.

Railroads. The Congress of the United States should speedily enact legislation providing for the early return under Federal charters to their owners of all railroads now being operated by this government under Federal regulations permitting the elimination of wasteful competition, the pooling of equipment, combinations or consolidations through ownership or otherwise in the operation of terminals, and such other practices as will tend to economies without destroying competition in service.

Means of Communication. We are opposed to government ownership and operation of telegraphs, telephones, and cables.

Merchant Marine. We recommend that the construction of a great merchant marine be continued and amplified, and that its operation under American control be kept safe by such legislation as may be necessary to insure its stability and its lasting value to American industries.

Port Facilities. The recommendations of the Port and Harbor Facilities Commission of the United States Shipping Board for development of ports are supported. Vessels of foreign register needed for our commerce by sea are attracted to those ports which are best fitted to coal, to load and to unload cargoes, and thus provide means for a quick turn-around. After ascertaining the port facilities of European countries, and their plans for further development, the Commission has recommended that there should be a local port commission at each of the important ports upon our coasts, that upon these commissions there should be representatives of industrial, commercial, and railroad interests centering at the port, that facilities should be installed to meet the needs of the port, and that a zone system should be arranged by which exports and imports would flow through these ports which are within economic transportation distance of the points of origin and destination. There should be co-operation with the Facilities Commission in its task of expanding means which will enhance the position of the United States among maritime nations.

Public Utilities. Public utilities have faced difficult problems, which have been accentuated by conditions arising out of war. The development and efficiency of such a utility as local transportation has immediate importance for every community. It is recommended that the Chamber of Commerce of the United States should appoint a committee to investigate and study the question of local transportation as it relates to the control of rates and service, franchises, taxes, the attraction of capital into the business, and such other questions as the committee may find pertinent. Such a committee should report its recommendations to the Board of Directors of the National Chamber, and the Board should deal with them in accordance with the established procedure of the Chamber.

Water Powers. Industrial activity is dependent upon the available supply of power. A bill which would affect the development of hydroelectric power upon waterways and lands which are subject to Federal jurisdiction is now before a committee of conference between the two Houses of Congress. It is important in the public interest that Federal legislation on this subject should be enacted without further delay. We accordingly urge that the conference committee arrive at an acceptable form of legislation in season for enactment at this session of Congress.

European Commission. The business men of the United States, having devoted their energies and resources toward the [illegible] of the war, regardless of sacrifice or burden, in support of the principles for which this country fought, appreciate the necessity of continuance of unremitting effort in order that the world may be restored to normal conditions as quickly as possible and the blessings of peace brought to all people.

In the accomplishment of these results the highest efficiency of the great commercial and industrial powers of our own country and that of the Allied nations will be developed only through co-operative effort and common counsel.

In order, therefore, to contribute to the fullest toward the prompt solution of the problem presented, the Chamber of Commerce of the United States is requested to enlist the co-operation of national bodies devoted to the extension and promotion of American commerce and particularly foreign trade, in the appointment of a commission representative of American business, which shall proceed without delay to Europe and establish machinery for the following purposes:

(1) To study at first hand the reconstruction needs of European countries in conjunction with business men of these nations in order to advise the business men of the United States as to how they may be most helpful in meeting the necessities of Europe and caring for the interests of American industry and commerce.

(2) To be available to the peace delegates of the United States for any needed information which they may be able to present or for any other aid which may be given by the business men of the United States through the medium of such a commission.

The Chamber of Commerce of the United States also is requested to appoint members of the Commission to represent the business men of the United States at the forthcoming meeting of the Permanent Committees of the International Congress of Chambers of Commerce.

Markets for Foreign Trade. We strongly urge upon our government the vital necessity of encouraging and developing our foreign trade through all appropriate means possible, in order that the production of industry may afford employment to wage earners and prosperity to the nation.

South American Relations. It has long been the policy of this nation to cultivate relations of close sympathy with the nations of the Western Hemisphere as expressed in the Monroe Doctrine. We believe that these relations should be supplemented and strengthened by a vigorous development of our commercial and financial associations with our neighbors of North and South America.

The government's control of shipping should be brought to the accomplishment of this purpose as soon as it is consistent with other urgent needs and the work of the Pan-American Union should be continued and broadened in scope.

Property Rights in Mexico. By provisions in the constitution adopted while much of the country was engaged in civil strife, and through subsequent legislation, Mexican authorities have threatened rights acquired by Americans in good faith, especially in minerals including petroleum. Against threatened confiscation the American government made formal protests. The attitude taken by the American government is heartily commended as in accordance with obvious justice.

Education in Foreign Commerce. In the larger opportunities which are to be opened to American business men to play a part in the international commerce of the world, the need will be felt for more men who are trained to a knowledge and understanding of the language, the business methods, and the habits of thought of foreign lands. Complete success can only come to those who succeed in putting themselves into full accord and sympathy with the peoples with whom they are to deal.

We urge upon our industrials that they take steps to provide opportunities to young men to obtain an education in the practices of overseas commerce and finance and in the practical use of foreign languages.

We call the attention of the various departments of government and of educators to the importance of this matter and ask that special efforts be made to supplement the valuable work already done and to open up every facility to the furtherance of a successful prosecution of this educational work.

Cost Accounting. It is the sense of this convention that uniform cost accounting should be adopted by industries.

National Trade Associations. The experiences of the war have clearly demonstrated the value of national trade organizations and their service to the country as well as to industry.

This conference heartily approves the plan of organizing each industry in the country in a representative national trade association and expresses the belief that every manufacturer, jobber, and producer of raw materials should be a member of the national organization in his trade and cordially support it in its work.

Some Developments in the Electrical Industry During 1918

By John Liston

Publication Bureau, General Electric Company

Although the activities in the electrical industry during 1918 were mainly concentrated [illegible] tion and application of existing designs to the war requirements of the country, and hence [illegible] new apparatus and new applications was restricted, there was still a surprising number of achievements of a notable character that are to be recorded.—Editor.

The electrical industry is indissolubly connected with every phase of our war-quickened production; in the mining of coal and ores, the refining and shaping of metals for ships and munitions, the making of chemicals, the handling and refining of foodstuffs, and in the operation of freight terminals and shipyards.

Not only in the production but in the operation of a considerable percentage of our military equipment is electricity depended on: The movement of guns, turrets, ammunition hoists, and steering gear of our battle fleets; the energizing of telephone, telegraph, radio, and X-ray outfits; the underwater travel of our submarines; the protective lighting for construction; and the stabbing rays of our military searchlights on land and sea are all rendered possible by the application of electrical energy.

Back of all of these operations are the generating equipments large and small; the mammoth central station transmitting current to hundreds of centers of industry in large areas, the smaller plants in isolated mines, mills, yards, factories, and on shipboard, down to the tiny portable generators utilized for field work.

Under these conditions it was entirely natural to limit new devices in the electrical industry to those approved by the authorities as being of direct advantage to the speeding up of our war production. These circumstances explain the relatively small amount of distinctly new apparatus which was produced during the past year, as compared with previous periods when efforts were to a very large extent concentrated on commercial problems.

Nevertheless, the year 1918 saw a number of notable achievements in the electrical industry, the completion of important equipments begun prior to our entry into the war, a vastly augmented production along certain lines necessitated by war demands, and a certain number of improvements of such character that their development expedited production and secured increased economy

Fig. 1. 45,000-kw., 50,000-kv-a. Curtis Steam Turbo generator

Assembly of Large Steam Turbine Generators, Schenectady Works, General Electric Company
This view shows one bay of building No. 60 in which single-unit steam turbine generators ranging from 2500 to 50,000 kilowatts in capacity are assembled and tested

or efficiency, and were therefore authorized despite the general limitations imposed on the industry as a whole.

As in previous articles on this subject the electrical apparatus referred to was produced by the General Electric Company, but serves as an indication of the tendencies, in design and construction, of the electrical manufacturing industry as a whole.

Turbines

Steam turbines have been very generally adopted for the propelling equipment of battleships, destroyers, and cargo boats, and they also constitute the prime movers for generators which supply current for the operation of shipyard machinery, nitrate plants, and a great variety of industries engaged in war work.

For this reason in 1918 as in 1917 every effort was made to increase the production of turbines of types already developed. The result of specialization on established types, together with increased factory facilities, is shown by the fact that in spite of labor shortage the kilowatt capacity of the turbines shipped in 1918 was approximately three and one half times greater than the maximum production prior to 1916.

The 45,000-kw., 50,000-kv-a. turbine-generator (Fig. 1) built for the Detroit

Fig. 2 Fig. 3
Turbo-generators for Locomotive Headlights

Edison Co., which was referred to in last year's REVIEW, was completed and installed together with the auto-transformer for stepping up the generator [illegible] to 21,000 volts. Both the [illegible] and the transformer [illegible] capacity for apparatus of their [illegible].

A small Curtis turbine [illegible] Figs. 2 and 3 was specially [illegible]

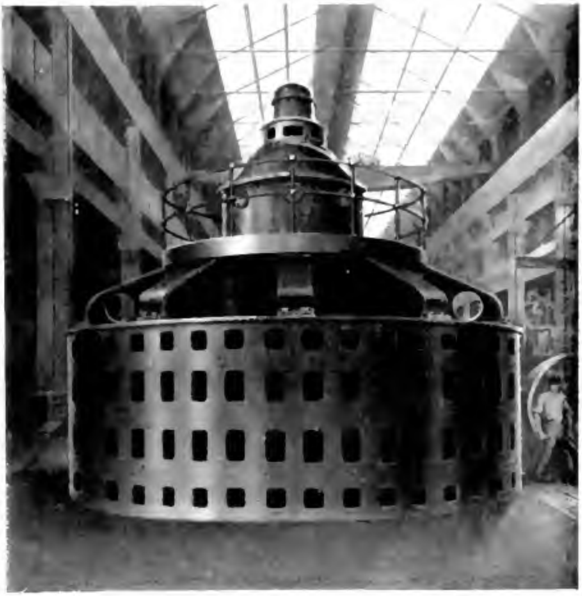


Fig. 4. 32,500-kv-a., 150 r.p.m., Three phase, 25-cycle, 12,000-volt Waterwheel Generator Now Under Construction for the Niagara Power Co. When completed it will have greater capacity than any existing waterwheel-driven unit

power for the operation of incandescent headlights and cab lamps on steam locomotives, and has several unusual features. It weighs approximately 275 lb., is 16 inches high by 22 inches over-all length, and can be wound for either 175 watts at six and one half volts or 500 watts at 33 volts.

A pressure-reducing valve maintaining about 100 lb. nozzle pressure provides for operation on boiler pressures ranging between 125 and 225 lb., and due to the action of this pressure regulator a constant speed is maintained with constant load.

Load regulation is obtained by the use of a magnetic brake consisting of a radial pole piece with a differential winding mounted on the hub of the magnet and a copper disk riveted to the face of the turbine wheel.

This copper disk rotates about the stationary pole piece so that when the magnet is energized eddy currents are induced in the disk, thus producing a drag upon the turbine wheel which is proportional to the extent to which the pole piece is magnetized.

The series and shunt windings of the brake magnet are so proportioned that when the machine is fully loaded the series coil neutralizes the effect of the shunt coil, and consequently no magnetization takes place and there is no drag on the copper disk. If part of the lamp load is removed, thereby decreasing the current through the series coil, the shunt coil magnetizes the pole piece and produces a drag upon the turbine disk which slows the machine down enough to maintain practically constant voltage at the decreased load.

With this method of governing, practically constant voltage is maintained from no load to full load. It is also impossible to burn out field and armature coils, due to the fact that with an overload or short circuit the brake magnet slows the speed of the machine down as in the case of an underload.

Fig. 5. Nine of the Ten 10,000-kv-a., Three-phase, 6600-volt Cedar Rapids Generators Installed During 1914. Two additional units installed in 1918 are equipped with spring thrust bearings

Alternating-current Machines

The maximum rating for waterwheel generators was increased to 32,500 kv-a. by the machine shown in Fig. 4 which is now under construction.

Apparently due to the increasing cost and difficulty in obtaining coal in foreign countries, the exceptional demand for waterwheel generators, which was referred to in last year's REVIEW, continued unabated during 1918. A considerable number of generators of varying capacities were designed and constructed for operation in France, Italy, Spain, and India. Among these were two 10,500-kv-a. units for Italy and six 10,000-kv-a. units which formed part of a complete hydroelectric equipment for the Andhra Valley development in India.

In addition to the 10,000-kv-a. generators, this development will utilize two 12,500-kv-a., 22,000-volt synchronous condensers which are now under construction. These units represent the maximum voltage rating for synchronous condensers.

The generators for foreign countries include four 108-pole, slow-speed, vertical-shaft units which have greater physical dimensions than any heretofore constructed for foreign shipment. They are to be installed in the Mauzac Power Station, France, are rated 2857 kv-a., 55.5 r.p.m., 5500 volts, three-phase, 50 cycles, and are designed to operate under hydraulic heads of from three to five meters. Their dimensions are: diameter 26 ft. 4 in., and height 13 ft. 6 in. The spring thrust bearings with which they are equipped will each carry a live load of 310,000 lb.

Spring thrust bearings were applied to larger generators than in preceding years. Two of the 10,000-kv-a., 55.6-r.p.m. generators (Fig. 5) supplied to the Cedars Rapids Manufacturing and Power Co. of Quebec were so equipped, the live load imposed on the bearing being 550,000 lb.

Notwithstanding this great weight, the machines when started, run, and stopped in varying tests showed that no wiping of the contact surfaces had occurred and there were no indications of excessive pressure or temperature at any point. There was also an entire absence of the noise usually associated with the operation of large suspension thrust bearings.

These bearings have an outside diameter of about 56 in. and inside diameter of 28 in.

While not an electrical development, it may be interesting to note that this type of thrust bearing has recently been applied to the propellor shafts of ships.

The first installation of this kind was made on a twin screw scout cruiser in March 1918, and while it has been impossible as yet, for service reasons, to open and examine these bearings for possible wear, they appear to be functioning perfectly. The propellor shafts revolve at 380 r.p.m. and the bearings each sustain a maximum thrust of 75,000 lb.

Direct-current Machines

A study of methods to protect direct-current machines from flashing, due to short circuits, has been in progress for several years. During 1918 there were placed in commercial operation a number of machines, particularly synchronous converters, with automatic substation control, equipped with a type of flash barrier (Figs. 6 and 7) that has greatly reduced the damage possible when short circuits occur.

Fig. 6. Flash Barrier for Direct-current Machines

These barriers are also being used on 3000-volt motor-generator sets built for the Chicago, Milwaukee & St. Paul Railway. Tests recently made show that they are very effective.

The production of submarine motors rated at 750 h.p. involved special features of design due to the exceptional character of the service required of them.

These motors drive the submarine when it is submerged, and are also driven as generators by the oil engine to charge the storage batteries when the boat is on the surface.

Fig. 7. 500 kv-a., 600 volt Synchronous Converter Equipped with Flash Barriers

The motors are enclosed and are cooled by forcing air with a separate blower into the commutator end of the machine and out through the fields and horizontal ventilating ducts through the armature to an exit at the back end of the motor. The requirements for quiet running and minimum magnetic disturbances involve a special arrangement of the armature punchings.

Electric Traction

In the electric traction field, the manufacture of equipment was generally limited to standard designs and, for the most part, to city and interurban equipment required because of war conditions, such as cantonments, shipyards, munition plants, and other war industries.

Where financial arrangements could be made, very necessary rehabilitation of properties was undertaken to cope with the rapidly increasing costs of operation. With the exception of projects already initiated, no further steps were taken during the year looking to the electrification of steam railroad systems.

Electric railways of necessity added to their power house equipment and, where power was purchased, have been the indirect cause of increasing the capacity of power and lighting companies. One of the most consistent sellers in the electric traction field was the automatic substation, the number of orders equaling, if not exceeding, the previous year's business.

Electrification of Steam Roads

Work on the electrification of the Othello, Seattle, and Tacoma divisions of the Chicago, Milwaukee & St. Paul Railway is now approaching completion over the entire 211-mile zone, and the change from steam to electric operation is predicted early in the present year. Bonding and line construction work is nearly finished, substations are being equipped (Fig. 8), and locomotive delivery will probably be started in the early spring.

Fig. 8. One of the Eight 2000-kw., 3000-volt, Three unit Synchronous Motor generator Sets Under Construction for the Chicago, Milwaukee & St. Paul Railway, Othello, Seattle & Tacoma Division. Twenty-three similar sets are in service on the original electrification from Harlowton to Avery

On the original 440-mile zone electric operation continues to give the utmost satisfaction. The 44 locomotives, 14 substations, and 600 miles of line material, all of which were supplied by the General Electric Company, have given practically no trouble since being put in service early in 1916.

Service is gradually being inaugurated on the electrified terminal of the Canadian Northern Railway where six 83-ton, 2400-volt, direct-current locomotives are hauling trains under Mount Royal into the new Montreal Terminal.

During the year, the New York Central Railroad put into service a 20,000-kv-a. Curtis turbine generator set at the Port Morris Power Station. This unit, which is of the most improved type, relieves the four vertical units of equivalent rating from continuous service and, because of its much higher efficiency, has effected a great saving in coal.

One of the large foreign orders was for the electrification of the Cienfuegos, Palmira & Cruces R. R. in Cuba. This contract includes 14 car equipments, each with four GE-263, 55-h.p., 600/1200-volt motors (Fig. 9), PC-101 control, G-E straight air brakes, and four 60-ton locomotives each equipped with four GE-251 600/1200-volt motors and PC-201 control. The electric power equipment includes two 8000-kv-a., waterwheel driven generators, three 500-kw. synchronous motor-generator sets for 1200 volts direct current with the necessary transformers, switchboards, and switching equipment, and a portion of the line material.

Automatic Railway Substations

There are now in actual service 26 automatic railway substations installed by the General Electric Company, one of these (Fig. 10) being a two-unit station. As in the single-unit stations, the functioning is entirely automatic, the second unit starting up when the load demand exceeds certain predetermined limits and dropping out when the demand is reduced to the capacity of a single machine.

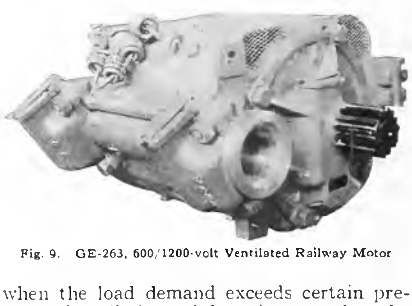


Fig. 9. GE-263, 600/1200-volt Ventilated Railway Motor

The Salt Lake, Garfield & Western Railway, formerly a steam road, placed a contract for a complete equipment to change over to electrical operation. Two automatic substations are now being installed, each equipped with a 600-kw. synchronous motor-generator set, supplying a trolley potential of 1500 volts direct current.

Fig. 10 Automatic Substation Equipment Installed for the Rhode Island Company, Oakland Substation, Controlling Two 300-kw., 600-volt Synchronous Converters

The rolling stock includes six motor cars, each equipped with four GE-240 750/1500-volt motors and PC-101 control. An interesting feature of this equipment is the small motor-generator set* for supplying 32-volt current to the control and lighting circuits.

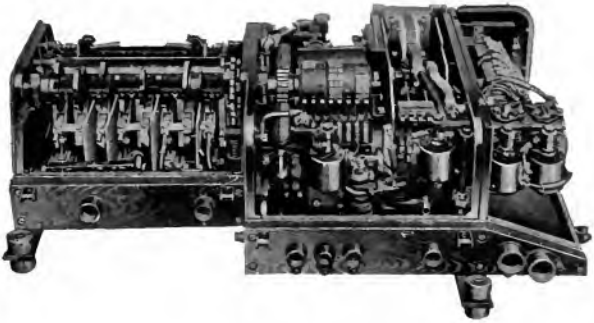


Fig. 12. Type PC-5 Controller

There are under construction about 30 additional automatic substation equipments for controlling railway units of various sizes, both synchronous converters and motor-generator sets.

* General Electric Review, Feb. 1918, p. 124.

City and Interurban Railway Equipment

As a means of keeping down operating costs, several railways have purchased new substation and car equipment which has the advantage of higher efficiency and greatly reduced maintenance cost. One of

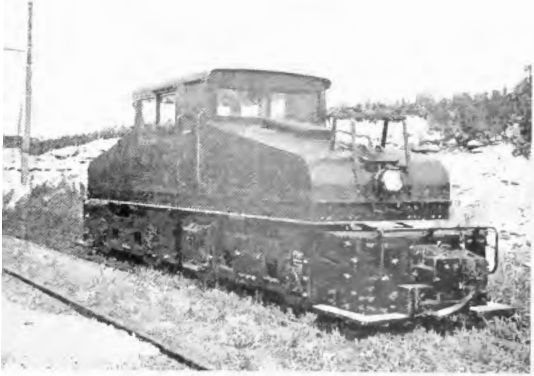
Fig. 11 Light-weight Safety Car Equipped with GE-258 Motors Keokuk Electric Co

these roads, the Philadelphia & Western Railway, is a third-rail system connecting Philadelphia and Norristown and operates 34 miles of track. The entire power distribution system is being re-constructed, changing the frequency from 25 to 60 cycles, and arrangements have been made for the purchase of power. Two new substations are being constructed and re-located, and a third substation equipment is being installed in the power house. The new equipment includes seven 750-kw. synchronous converters together with transformers, switchboards, and signal power equipment.

Another interesting improvement was undertaken by the Cincinnati, Lawrenceburg & Aurora Electric Street Railway, operating about 32 miles of interurban line between Cincinnati and Aurora, Ohio. The road was originally operated from an engine-driven direct-current power house which is now being replaced by two automatic railway substations, each equipped with a 200-kw., commutating-pole, 60-cycle synchronous con-

Fig 13. 60-ton Electric Locomotive Built for Sacramento & Northern Railroad

Fig. 15 20-ton Standard Gauge Storage Battery Locomotive Built for Newport News Shipbuilding & Drydock Co.



14. 40-ton Haulage Locomotive Built for the Britannia Mining & Smelting Co.

Fig. 16. 20-ton Storage Battery Locomotive Used for General Freight Car Shifting

verter. Power will be purchased and the operation of a power house dispensed with.

Seven new up-to-date passenger cars were also purchased, each equipped with four GE-258 motors. The weight of these cars is less than half that of the old rolling stock, thereby cutting the power consumption in two. The full benefit of this saving is realized by the purchase of power, thus avoiding the standby and light load losses entailed in the operation of an isolated power plant.

The light-weight safety cars (Fig. 11) equipped with GE-258, 25-h.p. motors, K-63 control and CP-25 compressors have been most popular in the replacement of older and heavier equipment. The Winnipeg Electric Railway purchased 100 GE-258 motors for use on 100 reconstructed cars, making thoroughly modern equipments.

The GE-247, 40-h.p. motor has also been a favorite, especially in the vicinity of shipyards and other war industries. More than 500 of these motors have been furnished for the lines running to Hog Island and 100 motors for the Philadelphia Rapid Transit in the city of Philadelphia.

This company also purchased 400 GE-203-P, 50-h.p. motors for the League Island Navy Yard Line. The Boston Elevated Railway also ordered 400 GE-247 motors for use on city lines, duplicating a previous order for the same number. A larger part of the GE-247 motors mentioned are operated with Type PC-5 control.

In the rehabilitation of the United Traction Company's equipment in Albany, N. Y., 14 two-motor equipments were used. The motors are GE-203-P, 50 h.p., and the control is PC-9.

Other important orders are as follows:

Twin City Rapid Transit Co.	200 GE-200 Motors
New York Municipal Railway (making a total of 1200)	200 GE-248 Motors
Capitol Traction Company	80 GE-247 Motors
Washington Ry. & Elec Co. (Both above use K-66 control for 2-car train operation)	200 GE-200 Motors
Newport News & Hampton Ry. & Lt. Co.	40 GE-247 Motors and PC-5 Control (Fig. 12) 72 GE-203-P Motors and K Control
Boston Elevated Railway (replacing older type)	264 GE-203-P Motors
Sacramento & Northern R. R. (Fig. 13)	1 60-ton, 600-volt Elec. Locomotive
So. Manchurian Ry.	4 56-ton, 1200-volt Elec. Locomotives
Commonwealth Edison Co.	1 60-ton, 600-volt Elec. Locomotive

Mining and Industrial L[illegible]

A 30-ton [illegible] [illegible] which [illegible] and height [illegible] by the Britan[illegible] [illegible] Dr[illegible]

Fig. 17. Arrangement of Storage Batteries on 20-ton Locomotive

haulage locomotives may be designed to give great tractive effort under exceptional route limitations.

At 20 per cent tractive effort (16,000 lb.), its speed is seven m.p.h. and as it has to pass through a relatively low tunnel its dimensions were necessarily restricted. Its over-all length is 31 ft. 8 in.; width 6 ft. 1 in.; and height over cab 9 ft.

The largest storage battery locomotive (Fig. 15) was placed in service about the middle of the year. It is a 25-ton standard-gauge double-truck unit and is used for general freight car shifting (Fig. 16) by the Newport News Shipbuilding and Drydock Co.

The 200-volt battery (Fig. 17) with a capacity of 630 ampere-hours consists of 200 cells arranged 100 in series, and supplies current to four series-wound motors which drive through single reduction gears; series-parallel control is provided. As a result of the satisfactory service secured with this locomotive a duplicate was recently ordered and is now under construction.

A smaller standard-gauge storage battery locomotive rated at 12 tons (Fig. 18) and used

Fig. 18. 12-ton Storage Battery Locomotive Used for Yard Shifting and Provided with Special Footboard

for yard shifting has certain unusual features. The two series-wound motors drive through single reduction gears and current is supplied by a 450-ampere-hour, 160-volt battery. Series-parallel control is used with straight air brakes.

Around the frame of the locomotive there is a footboard on which the operator can stand or walk from end to end of the locomotive platform. It is therefore easy for him to not only run the locomotive but also to throw switches when required without leaving the locomotive; the necessity for a switchman being thereby avoided.

Mine Hoists

Although in the field of mining as in so many others new development was curtailed to a great extent to allow production in the greatest possible measure with existing equipment, nevertheless some notable electric hoist installations went into commission. These are found especially in the soft coal fields of the Middle West.

At the Middle Forks Mining Company, Benton, Illinois, a new electric shaft hoist was put into successful operation. It is driven by an 1150-h.p., 450-volt, direct-current motor, the armature of which is mounted on an extension of the drum shaft. The motor operates on the Ilgner Ward-Leonard system receiving power from the alternating-current supply main through a flywheel motor-generator unit, which in conjunction with the regulating devices equalizes the

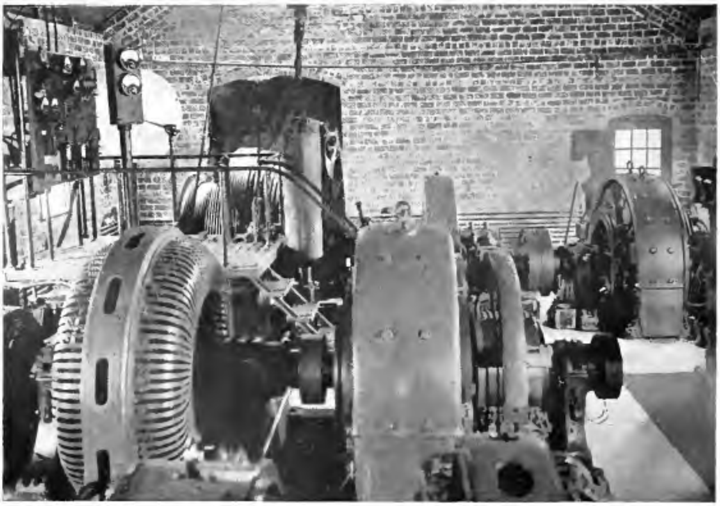


Fig. 19. Coal Hoist Driven by 800-h.p., 350-r.p.m., Direct-current Motor Through Reduction Gears and Controlled by Ward-Leonard System. Synchronous motor-generator set in foreground

power demands. The demand on the system is maintained to an approximately uniform value of 500 kw. during hoisting, although the requirements of the hoist during acceleration approximate 1200 kw.

The Vandalia Coal Company has now in regular service three new electric hoists at its shafts in southern Indiana. All operate on the Ward-Leonard system, the motors of the power sets in these cases being of the synchronous type, no flywheels being used. Two of these hoists are driven by 800-h.p., 350-r.p.m., 500-volt motors (Fig. 19) through herringbone gearing, and the other, a converted steam hoist, by a 675-h.p. geared motor at 400 r.p.m.

An installation of especial interest now nearing completion is that of the Chicago, Burlington & Quincy Railway at its mine at Valier, Illinois. A 1350-h.p. motor direct-coupled to the drum shaft will drive this hoist and will receive its power through a flywheel motor-generator set. The unique feature of the control consists in its semi-automatic character. The trip is started by a man at the bottom of the shaft by throwing a control lever, and slowed down and stopped automatically at the dump. This installation is noteworthy also from the fact that the coal is hoisted in a specially designed skip of 22,000 lb. capacity, instead of in cars, as is the usual manner.

Among the large hoist equipments placed on order during the year may be mentioned that for the McKinney Steel Co., for main and supply shaft hoists at its iron mine near Bessemer, Mich. The equipment for the main hoist will consist of a 1600-h.p., direct-coupled motor at 80 r.p.m. with a 1000-kw. flywheel motor-generator set, the wheel weighing approximately 45 tons. The supply hoist will be operated by a 400-h.p., 2200-volt, three-phase, slip-ring induction motor. This equipment when installed will be the largest electrically operated hoist in the northern iron country.

Mine Pumps

A mine pump equipment of exceptional capacity was under construction for the Randfontein Central Gold Mining Company, South Africa. It consists of four units for installation underground, each comprising a centrifugal pump in two sections driven by a direct-connected, 1750-h.p., 1500-r.p.m., 2000-volt, slip-ring induction motor, a section of the pump being on either side of the motor. Each unit will have a capacity of 1200 gallons of water per minute against a total head of 2600 feet, which corresponds to approximately [illegible],000,000 gallons of water per 24-hour day for the entire equipment.

Oil Wells

There was a rapidly increasing adoption of oil well motors in California, where their use had long been established, and, in addition, there was evidence that interest in the subject of electrification had been particularly aroused in the mid-continent and Gulf coast oil field.

As a notable indication of this movement the Empire Gas & Fuel Co., one of the largest producers in Kansas and Oklahoma, after an extended survey of its operating conditions in Kansas placed an order for 700 equipments to be added to 25 or 30 which had previously been secured, and the work of installation is now in progress. Although the total number of oil well motors already in operation numbers several thousand, this is the largest electrification so far attempted by any oil company in this country.

Many other oil companies now desire to electrify extensively, but are unable to do so because of the lack of available power. The central stations, though they are alive to the possibilities and have made plans for large extensions, are at present obliged to hold the latter in abeyance because of the financial conditions produced by the war. These limitations are of course only temporary.

Recently, the United States Fuel Administration has evinced an active interest in the electrification already completed, and is now conducting a careful investigation through its Bureau of Oil Conservation to determine whether this form of drive shows material economies in oil production and fuel consumption.

Steel Mills

A novel electric drive was designed for operating a 1200-ton hydraulic bloom shear. This type of shear ordinarily derives its power from a steam-driven hydraulic intensifier. Since, however, in the Fairfield Works of the Tennessee Coal, Iron & Railroad Company no high-pressure steam would be available except by means of a boiler plant which would have to be maintained especially for this shear, it was decided to use electric power.

A rolling mill type reversing direct-current motor having a continuous capacity of 700

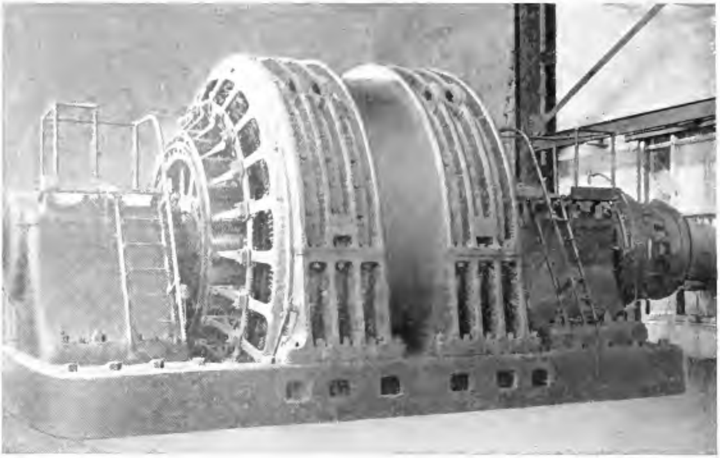


Fig. 20. Double Unit Reversing Blooming Mill Motor for 36-inch Blooming Mill. Trumbull Steel Co. Two 2500-h.p., 50/120-r.p.m., 600-volt shunt wound motors

h.p. at 86 r.p.m. and good for momentary loads of 350 per cent is coupled to a pinion meshing with a rack which drives the intensifier plunger forward and reverse. Power is supplied by a flywheel motor-generator set with the customary liquid slip regulator for equalization of the alternating-current input.

The control is Ward-Leonard but of a special type. Extremely rapid acceleration and retardation must be provided, as under the worst conditions of operation the motor is required to accelerate to full speed, run for about one half second at full speed, and retard to rest, all in $2\frac{1}{2}$ seconds. The control

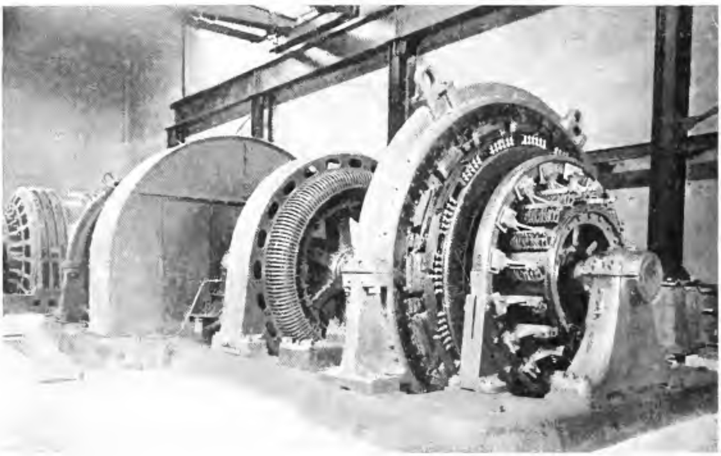


Fig. 21 Flywheel Motor-generator Set for Blooming Mill Motor Shown in Fig. 20.

system provides also "distance control." When the shear operator throws his lever a certain distance in either direction the shear will move through a proportional distance and will stop automatically at a position which corresponds to the operator's lever.

It is interesting to note that the maximum travel of the intensifier ram requires a total of only approximately three and one half revolutions of the motor armature.

The electrical equipment driving the 36-in. reversing blooming mill at the plant of the Trumbull Steel Company at Warren, Ohio, was put in operation in June and has been in successful operation since that time. This equipment has a double-unit, main-roll motor having a normal continuous capacity of 5000-h.p. (Fig. 20) and a momentary torque capacity of 2,000,000 lb. at one foot radius. Power for this reversing motor is derived from a flywheel motor-generator set (Fig. 21) consisting of two 2000-kw. generators, one 3000-h.p. induction motor, and one 50-ton flywheel.

The 4000-h.p., 83-r.p.m., 6600-volt mill motor with 110,000-lb. flywheel which drives the 36 by 110 in., three-high plate mill, known as the Liberty Mill, at the plant of the Carnegie Steel Company, Homestead, Pa., has continued to [illegible]. During the month of May, [illegible] approximately 21,000 tons [illegible] at a remarkably low power [illegible] per ton.

During the [illegible] approximately 35,000 [illegible] to the existing capacity [illegible] installed by the General Electric Company.

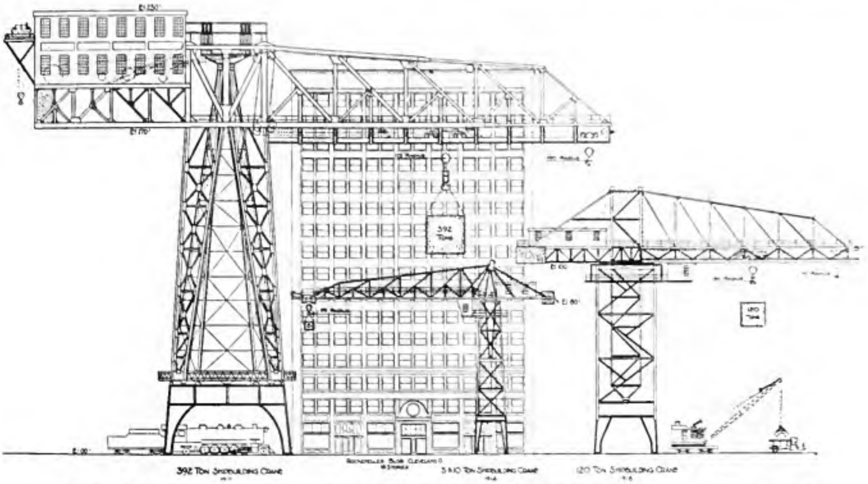


Fig. 22. 350-ton Shipyard Crane Drawn to Scale in Comparison with Well-known Objects and Maximum Sized Cranes of This Type Previously Constructed

Cranes

A 350-ton hammer head crane of such gigantic proportions as to overshadow all previous structures of this type was designed for shipyard use and the equipment was under construction and nearing completion at the close of the year.

Its general dimensions as indicated in Fig. 22 are: maximum height from base to top of machinery house, 230 ft.; length of boom, 300 ft.; hoist of block, 170 ft.; minimum radius, 41 ft.; maximum radius of the 50-ton block, 190 ft., and of the 350-ton block, 115 ft.

More than 3300 tons of steel will be used in the completed crane, including about 2500 tons of structural steel, a 330-ton counterweight, and about 35 tons of electrical apparatus.

The main hoist is divided into two duplicate units, each of 175 gross tons capacity, which can be coupled when the full hoisting capacity of 350 gross tons is desired. The crane is electrically operated and controlled throughout.

An indication of the size of the machines provided for the operation of the crane is found in the machinery house, located at the rear of the boom (Fig. 22) which is equipped with a 35-ton overhead three-motor traveling crane for handling the machinery during its installation and for subsequent repair or replacement work if required.

The main hoists, acting either independently or coupled together, have a full-load hoisting speed of 2.5 ft. per minute and a no-load speed of 10 ft. per minute. Each main hoist unit is driven by an 87-h.p. motor equipped for magnetic and dynamic braking.

has overload and low-voltage releases connected in each motor circuit.

The solenoid load brake, developed for alternating-current crane motors, constitutes an important advance for this class of apparatus, as a brief retrospect will show.

Some ten years ago, there was one general type of crane hoist mechanism. It made use of an electric motor with a solenoid brake on its shaft and a mechanical load brake in between the motor and the drums. The mechanical load brake acts as a coupling when a load is being hoisted; but when a load is being lowered, some ratchets drop into place and cause the mechanism to operate as a brake. Springs and screws inside of the device are so arranged that it is necessary for the motor to drive downward in order for either a load or an empty hook

Fig. 23. General View of Power Station and Coal Handling Equipment of the Baltimore Consolidated Gas, Electric Light & Power Co.

The two main trolley motors are each rated at $27\frac{1}{2}$ h.p. and have drum control, giving a maximum-load travel speed of 12 ft. per minute and a no-load speed of 100 ft. per minute. When both of the main hoist drums are used as a unit, the trolley drums are also coupled together; and as each pair of motors is thereby mechanically connected, the master controllers of each pair are provided with a mechanical coupling to insure the synchronous operation of the motors and equal division of the load.

The auxiliary hoist and trolley have each a single driving motor of the same capacity as one unit of the main hoist and trolley, and their control is identical. The slewing motor is rated at 87 h.p. and is provided with magnetic braking only.

Protection for the electrical equipment is insured by means of a panel board which

to be lowered. All of the potential energy which comes out of a body being lowered goes into the mechanical load brake in the form of heat and, in addition, some energy from the motor shaft also goes into the mechanism.

Subsequently, on direct-current cranes, this mechanical load brake was very largely superseded by a system which makes use of dynamic braking on the motor and a solenoid brake on the motor shaft. With this system, when a load is to be lowered and retarded, all of the energy is dissipated in rheostats. The only friction wear on the brake comes when the motor is to be retarded from about 25 per cent of full speed to zero; also when the motor is to be stopped after hoisting.

During 1918, the General Electric Company brought out for use with alternating-current crane motors a system which corresponds very closely to the dynamic braking system. A solenoid load brake is used. This is a device which will stop a motor in exactly the same manner as an ordinary solenoid brake, but can be energized from the primary and secondary circuits of the induction motor in such a way as to give braking action which is responsive to the speed of the motor in the same way that direct current dynamic braking is responsive to the speed of the motor. Thus, a load or an empty hook is lowered by means of regenerative braking at full speed without involving any friction wear, and is stopped and landed by means of the solenoid load brake.

particular interest in that the [illegible] hoist motor is located near [illegible] storage pile and 175 ft. from [illegible] in which the hoisting apparatus [illegible]

The stationary head tower, [illegible] and the traveling tail tower [illegible] high, permit the bucket [illegible] to reach any part of the [illegible] storage area. The conveying speed [illegible] 1100 ft. per minute and the [illegible] bucket when empty is about 8500 [illegible] when full somewhat over [illegible] lb.

A 150-h.p., 440-volt, 25-cycle motor [illegible] to drive the hoist through air-actuated clutches which are controlled by means of

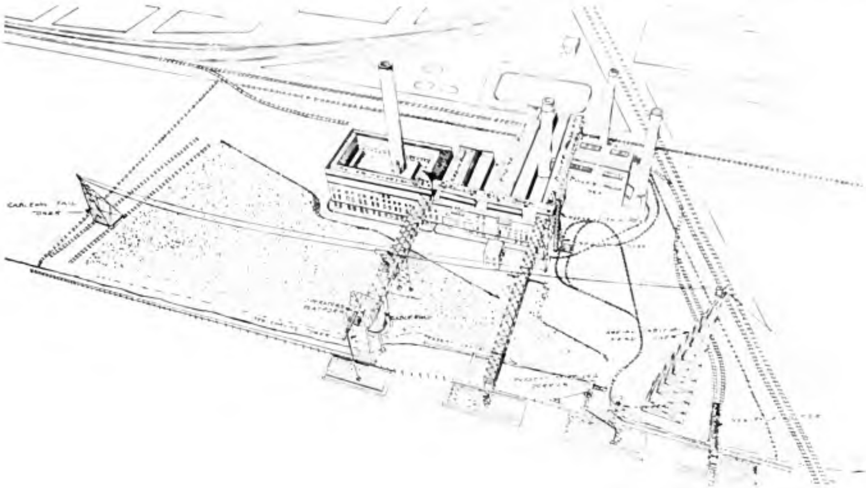


Fig. 23a. Perspective of Cableway and Coal Storage for the Power Station Shown in Fig. 23

This system has already greatly extended the usefulness of alternating-current crane motors, because it eliminates one of the most objectionable features on alternating-current cranes, viz., the mechanical load brake. This is especially true of cranes which are required to do a large amount of work, such as loading cranes.

Cableways

In order to secure rapid and economical service in storing and handling coal, the Baltimore Consolidated Gas, Electric Light and Power Co. installed an electrically operated cableway (Figs. 23 and 23a) about 1000 ft. in length, which is unusual for this

solenoid operated valves. The friction brakes are similarly air operated and electrically controlled.

Serving the coaling tower in which the cableway control is located is a motor-driven coal hoist for unloading barges, which is of special interest in that it attains a hoisting speed considerably in excess of that secured by any steam or electric hoist heretofore used. This hoist handles a two-ton bucket with a vertical lift of 115 ft., and gives three round trips per minute.

Winches

Twenty equipments for kite balloon winches were under construction, each consisting of a 50-h.p. series motor with drum controller, resistor, and protective panel. These winches are to be installed on battleships for towing kite balloons for observation purposes.

On account of extreme variation in rope stress, due to variable towing speeds and winds, a fine control over wide load ranges is necessary. Also, the control must be very flexible to compensate for the pitching of the vessel in a heavy sea.

A drum controller with 20 points is used, the first ten of which give torque variations from about 15 to 100 per cent of full-load motor torque, and these points will be used to give back torque braking to balance the rope pull after the balloon has reached the required elevation.

The winches are of very special design, as they must accommodate several thousand feet of rope which must be led to the winch through a small hole in the deck. This requires strain pulleys which take in the rope and feed it to a storage drum, on which the rope is evenly wound by a mechanical spooling device. This storage drum is designed for rapid removal for making quick changes in the cable. The cable also carries telephone wires for communication purposes.

The increasing use of electric equipment for docks, warehouses, etc. was indicated by an order for 62 duplicate alternating-current winch equipments, each consisting of a 30-h.p. slip ring motor, solenoid brake, drum controller, resistor, and protective panel to be used on cargo winches installed at the various quartermasters' terminals being built by the government at the various ports. They will be used for handling miscellaneous package freight up to about 3000 lb. in weight.

Four direct-current control equipments of novel design, also for use on cargo winches, are being built. They consist of a solenoid brake, contactor panel, resistor, master switch, and also a double portable master switch for each two equipments. The main master switch with each equipment will be mounted along with the remainder of the control equipment on the winch bedplate so that the winch can be operated singly by this controller when desired.

There is also a socket on the winch bedplate in which a plug can be inserted which connects the portable master controller to the winch. When this is done, a mechanical interlocking device locks the stationary master switch on the winch in the *off* position so that it is inoperative.

The portable switch is on the end of a 100 ft. length of cable, which cable contains control wires for two winches. This cable is devided into two sections at the winch end so that it can be connected to two winches at once. The portable switch has separate operating handles for each winch, so that one operator can control two winches at the same time, which is very desirable when handling cargo by the two-rope method, which is most commonly used. The portable controller enables the operator to walk from the side of the ship to the hatch and thus be in sight of his load at all times. This facilitates the work and dispenses with one winch man and a signal man.

Package Handling Machinery

The use of electrically operated machinery, such as storage battery tractors and trucks and portable conveyors and elevators, for handling package freight around warehouses, transfer yards, piers, etc., was slowly increasing prior to the war, but when compared with previous years, the increase in this class of equipment for 1918 is very marked, and is due largely to the drastic labor shortage and increasing cost of such labor as was available, combined with a growing appreciation of the economy inherent in a system of handling quantities of small packages by machinery.

A number of railroad transfer yards were provided with electric storage battery tractors which are used for pulling four-wheel trailers. These tractors superseded an expensive, slow, and frequently congested system which utilized hand trucks and direct manual labor.

Industrial Heating

The present construction of both the vertical, cylindrical, and horizontal high-temperature, heat-treating furnaces involves the use of heating units of heavy calorite ribbon wound up and down vertically over insulator spools which are supported between two horizontal channels running along the walls of the furnace. These channels are held together by spacing studs and bolted to vertical columns imbedded in the fire brick furnace lining. The channels, vertical columns, and all bolts and nuts must be made of a metal which will not oxidize at the temperatures involved.

While this construction has in general given satisfaction, the cost of the equipment is somewhat high, due to the large amount of calorite required for the supporting frame

Fig. 24. Arrangement of Furnace for Temperatures up to 1800 deg. F

work. A new method of construction was therefore developed in which all metal supports were eliminated, thereby materially reducing the cost of the equipment and at the same time simplifying it.

In connection with the changes in the construction of high-temperature furnaces, there was developed a special line of furnaces in which the heating chamber is of a semi-circular cross section. This permits of lining the arch of the furnace with ribbon windings which are curved edgewise, each convolution being spaced three quarters inch from the adjacent windings. In this way the work receives directly radiated heat from all points except from that immediately below where the work rests on the furnace floor. Also, by making the inside of the furnace in the shape of a semi-circle (Fig. 24), the furnace being lined with a high-quality refractory material, the heat is radiated from all parts of the furnace excepting the base very uniformly and at the highest efficiency obtainable.

These furnaces can be made in shapes which will take care of the many different kinds of work and will perform all the heat-treating operations which require temperatures up to 1800 deg. F. The temperature in any of these furnaces must, of course, be automatically controlled; this is accomplished by means of special instruments which both record and control the temperature of the work and the ribbon within very close limits.

A tilting type of electric brass furnace, which is shown in Fig. 25, has been in constant service for over a year and is used for melting very dirty scrap alloys. This particular furnace is of 300-kw. capacity and will melt approximately 1500 lb. of brass per hour. Unit equipments of this type have been designed for operation on either three-

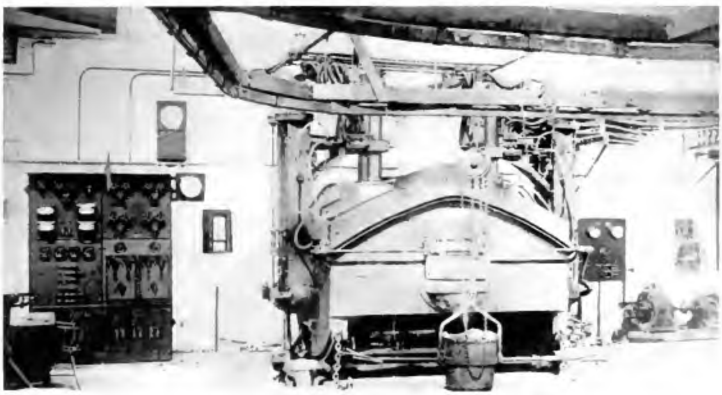


Fig. 25. 1500-lb. Electric Brass Furnace

phase, two-phase, or single-phase circuits in capacities from 600 to 5000 lb.

Heat is generated in the furnace by providing on either side a trench with carbon electrodes extending from the front to the back of the furnace; through the roof of the furnace on either side there are two graphite electrodes nearly making contact with the cross electrodes, just sufficient space being maintained by means of automatically controlled motors operating the electrodes to maintain a proper arc between the vertical and cross electrodes.

Fig. 26. Section of Cylindrical Shrinking Furnace

The cross electrodes and the lower end of the vertical electrodes are buried in carbon or coke, $\frac{3}{4}$-in. mesh, thereby producing a combination muffled-arc-resistance furnace. The charge is heated by the conduction of heat through the bridge wall of the hearth and by the heat radiated from the carbon bed to the arch of the furnace, and in turn reflected to the charge as in the ordinary reverberatory furnace.

This type of furnace has given excellent results, among which may be cited uniformity of metal, low metal loss, and an over-all economy exceeding that of the present-day fuel furnaces.

Repeated tests have shown that by means of the automatically maintained current input, overheating is avoided and standard alloys have been readily made in the electric brass furnace with a loss not exceeding three quarters of one per cent. These same alloys have then been remelted with metal losses not exceeding one half of one per cent. These losses, of course, are based upon a full-capacity charge in the furnace.

TABLE I

	Electricity	Oil	Coke
Fuel Price	$1\frac{1}{4}$ c. per kw-hr.	9.8 c. per gal.	$9.75 per ton
Fuel Quantity per ton	400–700 kw-hr.	50 per gal.	1200 lb.
Metal Loss—(Zn)	1.5 %	6%	3%
Zinc Value	10 cents per lb.		

TABLE II

COST PER TON TWENTY-FOUR HOUR DAY

	Electricity	Oil	Coke
400 kw-hr. C $1\frac{1}{4}$	$5.00		
50 gal. oil at $0.098 per gal		$4.90	
1200 lb. coke at $9.75 per ton			$5.85
$1\frac{1}{2}$ per cent metal loss (Zn)	3.00		
6 per cent metal loss		12.00	
3 per cent metal loss			6.00
Crucible cost per ton			8.00
Renewals and repairs to furnace	.50	.50	
Electrodes and coke			
5 lb. coke and 4.5 lb. graphite	.50		
Cost per ton (24-hr. day)	$9.00	$17.40	$19.85
Cost per ton (dirty scrap) 10-hr. day	12.75	17.40	19.85
Cost per ton (clean scrap) 10-hr. day	10.25	17.40	19.85

Table II gives the costs of melting brass (65 per cent copper and 35 per cent zinc) under average operating conditions in,

(1) An electric furnace as outlined above.
(2) An oil-fired furnace.
(3) A coke-fired furnace

The metal was poured at 1100 deg. C. and the comparison is based on the figures given in Table I.

The type of vertical cylindrical furnace which was designed originally for use in the shrinking processes in the manufacture of guns has also been adopted for similar commercial work on shafts and couplings, shrinking tires on metal wheels, etc.; and during the past year it was evolved into a fully standardized product.

The internal construction and the arrangement of the heating units are shown in Fig. 26. Furnaces consisting of more than one section are usually equipped with a simple hand control which permits bringing the charge up to temperature at a uniform rate throughout the length of the furnace; the maximum temperature being 1000 deg. F.

Fig. 27. Electric Rivet Heater Rear View Showing Switchboard Equipment

When a one-section furnace is used, it is ordinarily provided with automatic control, but this system may also be utilized, if desired, for furnaces of two or more sections by means of a master controller.

The ordinary means of heating rivets, such as the coke forge and oil or gas furnace, are far from satisfactory, involving the transportation or piping of fuel, the attention and time necessary for securing and regulating the desired heat, and the large loss of rivets due to overheating, scaling, welding together, etc. These conditions tend to make the present method both costly and inefficient.

Fig. 28. Electric Rivet Heater, Front View, Showing Rivet Holding Jaws

Recognizing the potential value of a rivet heater which would be efficient, economical, easy to operate, portable, and self-contained, there was developed a heater of the series conduction type which not only fulfills these conditions but heats the rivets in such a manner that the shank is hotter than the head, and as the result a more perfect upset of the rivet is obtained without marring the head.

This electric rivet heater (Figs. 27 and 28) consists of a cast frame having a transformer mounted on the base, surmounted by a water tank for cooling purposes and a series of water-cooled jaws supported in a vertical line in front. On the back of the frame is a switchboard which contains a main line switch, fuses, and a special swivel switch. The upper and lower jaws are connected to the secondary of the transformer and all are adjustable to accommodate rivets of different lengths.

The cooling of the rivet-holding jaws is accomplished by means of a cooling tank which is mounted on the frame and has rubber hose connections to the jaws which are hollow. This permits a free circulation of water through the jaws and prevents them from becoming overheated. On continuous eight-hour day operation, it is only necessary to replenish the water in the cooling tank once.

The adjustment of the jaws to take care of different size rivets is accomplished very simply as they operate on the principle of a rack and pinion; the adjustment being made on the bottom jaw first and then on each successive one to the top.

When the current passes through the rivets it heats them from the inside out, and

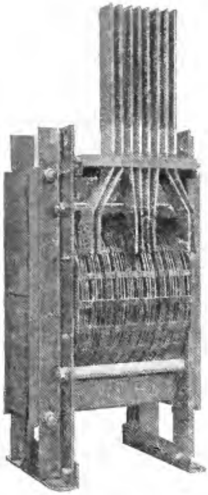


Fig. 29. 2775-kv-a., 12,000/190-volt, Single-phase, Water-cooled Transformer

Fig. 30. External View of 2775-kv-a. Transformer Shown in Fig. 29

The rivets are placed in series, one between each pair of jaws, thus closing the transformer secondary. Taps from the primary coil are brought out to the swivel switch on the back of the frame, giving different voltages across the secondary. As the secondary voltage is low, there is no danger of shock to the operator.

each time a rivet is removed and a new one inserted the circuit is broken, thereby allowing the other rivets to soak and receive an even distribution of heat. No time is lost in waiting for the heater to be brought up to temperature, as production begins immediately after throwing on the power.

TABLE III

RIVET HEATER CAPACITIES

Kv-a.	Number Jaws	Rivet		Estimated Rivets per Hour	
		Diameter	Length	Max. Rate	Min. Rate
6	2	¼–½	¾–2	250 (¼ x ½)	75 (½ x 1–1)
12	4	⅜–⅝	¾–2	360 (⅜ x ¾)	100 (⅝ x 2)
18	4	⅜–⅝	¾–2	450 (⅜ x ¾)	125 (⅝ x 2)
18	4	¾–1	¾–2	260 (¾ x ¾)	100 (1 x 2)
30	3	½–1	1½–6	450 (½ x ½)	100 (1 x 6)
30	4	¾–1¼	1–6	300 (¾ x 1)	125 (1¼–6)

It is a comparatively simple matter to move the rivet heater from point to point as construction proceeds, as it is self-contained and but two lead wires are required to supply energy to it.

Table III gives an outline of the various sizes of electric rivet heaters now available; the last two columns show the estimated number of rivets per hour that the different sizes of heaters will handle. The number will, of course, be affected by the composition of the rivets and any variation which may occur in the line voltage.

Fig. 31. Alternating-current Temperature Indicator (Front View)

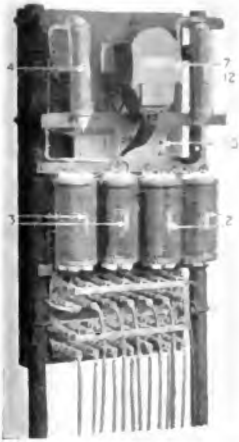


Fig. 32. Alternating-current Temperature Indicator (Rear View)

Transformers

A typical instance of the intensified production of transformers during 1918 is found in an order for 37 large units (Figs. 29 and 30) to be used in the operation of carbide furnaces.

The units are rated 2775-kv-a., 12000/190-volt, single-phase and are of the water-cooled, indoor type. Circular coil construction was used, having disk primary and helically wound secondary coils placed in interleaved groups on the center leg of a three-legged core. Regulating taps were provided in the primary to give a range of secondary from 130 to 190 volts in 10-volt steps.

This order was received February 1st, the first three units were completed and tested by May 1st, and the balance were finished before the end of July. Incidentally, these transformers, aggregating more than 100,000 kv-a. in capacity, constitute the largest single installation of furnace transformers.

The increase in the number and size of electric furnaces is indicated by the number of large transformers designed and under construction for this service. These include eight 7500-kv-a., 12500/160-volt; twenty-five 5500-kv-a., 66000/13200-volt, and seven 2000-kv-a., 13200/2300-volt, single-phase 60-cycle, water-cooled units, all of the circular coil construction with disk windings assembled interleaved. These three groups will have a total capacity in excess of 200,000 kv-a.

The demand for transformers to meet the special conditions involved in the operation of recently developed large spot-welding outfits resulted in the adoption of certain unusual details of construction.

On account of the high current, it is necessary to have the transformers as near to the work as possible in order to avoid excessive cost of low-voltage busbars. This requirement practically means that the transformer must be an integral part of the welding machine, and it is therefore necessary that it be as compact as possible.

For cases where it is desirable to know the actual temperature of a transformer winding while the load is on the transformer, an alternating-current type of temperature indicator was designed.*

The thermal element consists of a non-inductive exploring coil wound among the turns or strands of the transformer winding

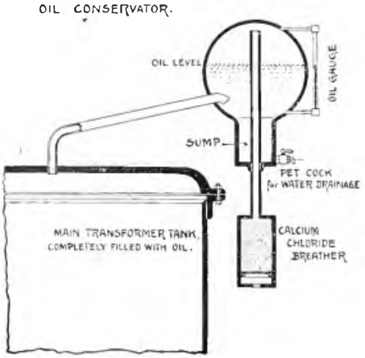


Fig. 33. Diagram Showing Operation of Oil Conservator for Transformers

and located so that it will follow closely the temperature of the transformer.

The exploring coil, connected through a suitable current transformer, forms one leg of a Wheatstone bridge. The remainder of the bridge is so designed that changes in the temperature of the exploring coil will affect the balance of the bridge in a predetermined manner, and this permits the calibration of the indicating meter accurately in Centigrade degrees.

One meter with its auxiliary apparatus may be used to indicate the temperature of a number of transformers, (Figs. 31 and 32) if the transformers are equipped with exploring coils.

In last year's REVIEW, mention was made of the use of transformers provided with separate expansion tanks or "conservators" on large high-voltage units. Many of these transformers have been in operation for some time; and as they have proved uniformly satisfactory, this construction has been standardized on all transformers of the highest voltages.

The conservator serves the triple purpose of, first, eliminating the contact between the warm oil in the main transformer tank and air, thereby preventing "sludging" or oxidation of the oil; second, eliminating moisture in the main transformer tank, since any condensation from the air takes place in the conservator and is trapped; third, eliminating air and gasses in the main transformer tank, thereby preventing explosions. Fig. 33 shows the essential features of the conservator.

The practice of shipping transformers filled with oil in a condition ready for immediate installation has received general approval, and this method was therefore adopted for practically all classes and sizes of transformers during the year. The saving effected in the transportation space required, and the added economy and convenience in installation work which this system rendered possible, is obviously beneficial to both the manufacturer and the user.

Induction Voltage Regulators

The tendency in the use of induction regulators has for several years been toward larger units.

Fig. 34. Induction Regulator, Automatic, Self-control Outdoor Type

The majority of the regulators built are naturally utilized for the control of lighting feeders but a continually increasing number are required for the control of power systems.

* "Temperature Indicator for Transformer Winding," by V. M. Montsinger and A. T. Childs, GENERAL ELECTRIC REVIEW, June, 1918, p. 396.

interconnected systems, and for special applications of which the following are noteworthy illustrations.

One operating company during the year installed a number of 600-kw., three-phase, 4600-volt regulators of the oil- and water-cooled design for the control of as many individual power feeders. This same size of regulator has also been designed in the self-cooled out-door type (Fig. 34), which is now being manufactured. This design is a radical departure from those heretofore used and embodies a number of marked improvements.

A 1000-kw. 11,000-volt, three-phase regulator (Fig. 35) of the forced oil design was built for the voltage control of a 70-mile interconnecting line between two generating systems. This is, as far as known, the largest induction regulator ever built. It has been installed for approximately one half year and is giving satisfactory service.

Fig. 35. 1000-kw., 11,000-volt, Three-phase, Oil-immersed Forced Oil Regulator

Two single-phase 770-kv-a., 10,000-ampere regulators (Fig. 36) were built during the year. Regulators of nearly as large a capacity had previously been used but the one shown typifies the latest construction for this class of apparatus. It is of lightweight design and for assembly in a boiler-plate tank provided with a water-cooling coil, the design being of the same external appearance as Fig. 35. The winding connections for the

Fig. 36. 770-kv-a. Induction Voltage Regulator Showing Internal Arrangement

rotor are brought out through an elongated hole in the cover, thus eliminating the mass of internal cables heretofore required; and by incorporating all recent improvements in design, the external dimensions and the weight have been reduced approximately 30 per cent.

The construction shown in Figs. 35 and 36 is typical of all of the larger sizes of regulators except the air-blast design. The cores and coils are assembled in a skeleton spider which combination may be assembled in a boiler-plate tank having a water-cooling coil for artificial cooling or in a similar tank with external tubes for self-cooling. This arrangement is an exceedingly flexible one and allows the use of standard parts to meet every requirement of service.

Lightning Arresters

The oxide-film lightning arrester* consists fundamentally of an insulating film placed

*"The Oxide Film Lightning Arrester" by Chas. P. Steinmetz, p. 590; and "The Oxide Film Lightning Arrester" by Crosby Field, p. 597, GENERAL ELECTRIC REVIEW, Sept. 1918.

on the surface of metallic plates between which there is a conducting powder, lead peroxide.

When subjected to over-voltage this insulation will be pierced, but the heat of the discharge will rapidly convert the lead peroxide into an insulating plug and stop the discharge.

Fig. 37. Compression Chamber Lightning Arresters for 10,000 and 13,200 Volts

The advantage of this arrester over the aluminum-cell arrester lies in the fact that, while it affords a high degree of protection, it does not require daily charging as does the aluminum arrester, and can be installed in a great many places where the need of daily charging by the aluminum arrester would preclude its use.

The compression-chamber multigap type of arrester for 10,000- and 13,200-volt circuits which was placed in commercial production early in the year (Fig. 37) consists of a combination of gaps and resistance rods mounted in a porcelain tube. The arrangement of the gaps and resistances is shown in Figs. 38 and 39. The series gaps indicated in these illustrations are of the same kind as those used in the previously developed compression-chamber arresters of lower voltage.

These two arresters do not have antennae, but sensitiveness to lightning disturbances is obtained through the combination of gaps, and gaps shunted by resistances. Two sets of two different shunting resistances are used giving a number of paths for the lightning discharge through the arrester. As there is a direct resistance path to ground from the series gaps, the initial discharge takes place very easily. The path which the discharge takes after passing through the series gap depends on the frequency and quantity.

Very high frequency will discharge straight across all the gaps. Discharges of lower frequency will take place through one of the shunt paths. The generator current which follows the lightning discharge will shunt to the resistance rods and will thus be limited to an amount that can be readily extinguished by the gaps.

The arrester, by virtue of this combination of gaps and resistances, will discharge at low rises in potential, is sensitive to lightning over a wide range in frequency, and will quickly cut off the generator current following the lightning discharge.

The Research Laboratory

Throughout the year the Research Laboratory worked on many special problems for the army and navy. In some cases the efforts proved abortive; in others the work is continuing, and where success was achieved the results were at once applied in production and assisted in warfare on land and sea, and in the air.

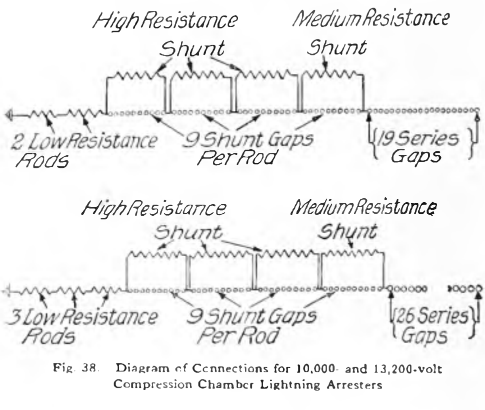


Fig. 38. Diagram of Connections for 10,000- and 13,200-volt Compression Chamber Lightning Arresters

The radiator type of Coolidge tube designed for continuous service, which was described last year, was put into quantity production. The principal development of the past year on these tubes was the perfection of a special alloy seal to replace the large platinum seal which was originally used, thereby releasing a large amount of platinum for other war uses.

There was also developed a new screen for fluoroscopic work, improved electrodes for army searchlights, and a small kenotron for use as a constant voltage regulator for small variable speed generators used in radio outfits.

Improvements were made in insulations, particularly in varnishes, which not only rendered possible substitutions for materials in which a war time stringency exists, but at the same time raised the standard of the G-E products of this class.

Electric Welding

The most important development in electric welding was not in the improvement of the electric equipments for welding, although certain new generator and control sets were produced, but in the widespread interest aroused by the investigations as to the practical utility of this process for shipbuilding.

Supplementing the research and experimental work along this line there was the discovery of the first welded boat,* which was built in America and launched in November 1915, the building of a welded barge in England, launched June 1918, and the preparation in both America and England of complete plans for the con[illegible] cargo steamer [illegible]

In order to meet the [illegible] for competent welding operators [illegible] Emergency Fleet Corporation [illegible] of school (Fig. 40) [illegible]

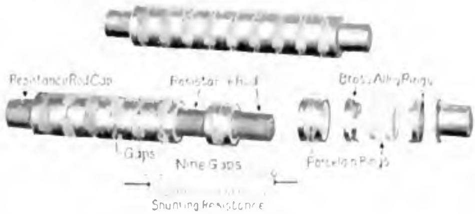


Fig. 39. Resistance and Shunted Gaps as Used in High voltage Compression Chamber Lightning Arresters

country where intensive courses of practical instruction under expert supervision are given.

Switching Apparatus

The application of a new idea in design and the development of a manufacturing process required to make the idea useful resulted in two new types of breakers which, for moderate voltages, current, and interrupting capacities, have many improvements over preceding types.

These breakers, Figs. 41 and 42, can be furnished for manual or for solenoid operation.

Both breakers are of "standard unit" construction, the standard unit consisting of

* GENERAL ELECTRIC REVIEW, December, 1918, page 844.

Fig. 40. School for Electric Arc Welders Established by the Emergency Fleet Corporation at the Schenectady Works of the General Electric Company

cover, two insulating bushings with studs and stationary contacts, movable contacts with contact rod, and oil tank. A single-, double-, triple-, or four-pole breaker is made up respectively of one, two, three or four

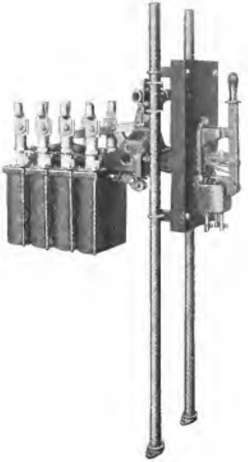


Fig. 41. Four pole Type FK-35 Oil Circuit Breaker

standard units plus frame, breaker mechanism, and operating mechanism.

Each standard unit is suspended from the breaker frame by attaching the cover of the oil tank to the lower surface of the frame. Each oil tank is held in position by hook bolts.

The rods connected to the movable contacts are readily accessible, and the length of the rods is adjustable. Thus it is easy to obtain accurate adjustment of the contacts.

The rods are of steel, pinned and riveted to a wooden rod which is fastened to the movable contacts. The wooden rod insulates the steel rod from the movable contacts.

The breakers can be equipped with an improved type of mechanical interlock either alone or in conjunction with time-limit interlock or a magnetic lock.

The breakers open by gravity assisted by compression springs on the operating rods. When the breaker is closed the springs are under considerable compression between the wood rods and the under surface of the breaker frame. When the breaker is released, the springs, one for each pole, increase very materially the speed at which the breaker opens.

A new design of direct-current solenoid (Fig. 43) for operating oil circuit breakers was introduced which has features attractive to operating companies. A noticeable improvement is the accessibility of the working

Fig. 42. Triple-pole Type FK-32-A Oil Circuit Breaker

parts. All mechanisms and all accessories are mounted on the upper casting of the solenoid which acts as the support of the

Fig. 43. Direct-current Solenoid for Operating Large Oil Circuit Breakers

complete solenoid; the pot, coil, pole piece, and armature are hung beneath it.

By this construction there has been made possible the ready accessibility and the visibility of the locking toggles, the trip coil, the auxiliary switches and the terminal board, as all are on the top of the solenoid.

The auxiliary switches are of a most approved design. They are of the rotary type, with the axis vertical, and as they are built on the standard unit principle, as many

Fig. 44. Triple-pole, Single-throw, 600-volt, 30-ampere Oil Circuit Breaker, Type FP-15

Fig. 45. Type FP-15 Oil Circuit Breaker with Oil Tank and Cover Removed

circuits as required can be supplied by merely adding one switch unit above the other. The finished auxiliary switch is enclosed by an insulated dust cover which clamps down over it.

Before leaving the factory the internal wiring of the solenoid is completed up to the terminal board; the operating coil, the trip coil, and the auxiliary switches being all wired together.

The small triple-pole, non-automatic oil circuit breaker known as type FP-15 (Figs. 44 and 45) was intended primarily for mounting on looms in textile mills. It can, however, be used to advantage to control small alternating-current motors in any service up to 30 amperes and 600 volts, but not exceeding ten horse power. It can be operated by hand at the breaker or from a distance by means of a shipper rod.

The contacts are so arranged that they snap in and out after the operating mechanism has moved a certain definite distance in opening and closing—a condition quite essential to satisfactory shipper rod operation.

The standard unit principle of design, as represented by Figs. 41 and 42, was applied also to breakers of higher voltage and interrupting capacity ratings. That is, the breakers are divided into interchangeable units made up as far as possible from [illegible]. The arrangement of the parts and method of operating them (Figs. 46-A, B and C) rather than the parts themselves determine the adaptability of the breaker [illegible] for various currents, pressures and [illegible]

Fig. 46-A. 2000-amp., 15,000-volt, Triple-pole, Single-throw Oil Circuit Breaker

Fig. 46-B. 800-amp., 15,000-volt Oil Circuit Breaker Standard Unit

Fig. 46-C. 2000-amp., 1500-volt Oil Circuit Breaker Standard Unit

In these breakers the principal parts that are common are the contacts, the general method of supporting the contacts, and (Figs. 47, 48, and 49) the construction of the operating rods and mechanism.

Fig. 47. Mechanism for Triple-pole, Single-throw, 2000-amp., 15,000-volt Oil Circuit Breaker

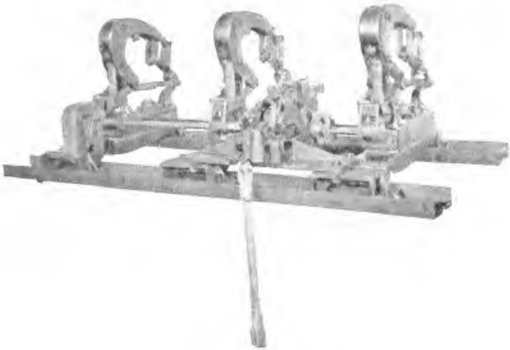


Fig. 48. Mechanism for Triple-pole, Single-throw, 800-amp., 25,000-volt Oil Circuit Breaker

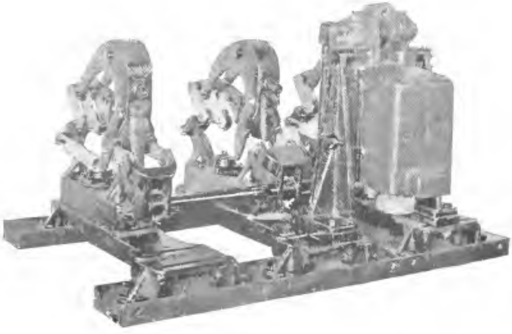


Fig. 49 Mechanism for Triple-pole, Single-throw, 800 amp., 15,000-volt Oil Circuit Breaker

For high pressures and large interrupting capacities the Type FK-36 (indoor) or FKO-36 (outdoor) circuit breakers (Fig. 50) were developed. These are similar in design except for the operating mechanism, which is somewhat different for indoor and outdoor use. Both types are built in several sizes, in each of which different combinations of bushings and contacts can be arranged to give a very wide range of application.

The breakers for use up to 73,000 volts are arranged for mounting on the floor or on a framework high enough to allow the lowering and removing of the tanks with the breaker contacts open.

For voltage of 95,000 and above the breakers are arranged for mounting on the floor or are supported on steel girders which rest on crecrete foundation pedestals. A pit is built between the pedestals so that the tanks can be lowered into it when removing them for inspection. If desired the steel girder can be set in the floor instead of on pedestals. In this case, however, it is necessary to make the pits deeper.

The contacts consist either of wedge-shaped copper blades and copper fingers, or of hollow copper plungers and segmental contacts mounted in the upper end of an explosion chamber which is located on the lower end of each bushing.

The contact fingers and contact head for 73,000 volts and above are surrounded by a static shield which carries a set of guide cams to force the movable contacts to enter into contact properly and thus prevent damaging of the contact fingers.

In some forms of these breakers the interrupting capacities are greatly increased by the use of an explosion chamber which surrounds the contacts. This chamber confines to the neighborhood of the arc the high pressures developed when the breaker opens under heavy load, helps to extinguish the arc, and reduces the mechanical pressures transmitted from the arc to the interior surface of the oil tank. The pressure developed in the explosion chamber causes an oil blast to cross the arc and greatly increases the interrupting capacity of the breaker.

These breakers are equipped with a new type of bushing which is the same for indoor and outdoor types and is used also for some types of high voltage lightning arresters and transformers.

Truck type panels (Figs. 51, 52, and 53) were improved in several details during the past year, the most important being the introduction of standard switchboard type oil circuit breaker bushings, bushing clamps and contacts for the part of the disconnecting switch that is mounted on the truck, and the use of steel channel and angle iron frames for supporting the movable parts of the disconnecting switches.

The line of panels was also extended to 1200 amperes at 7500 volts capacity, and up to 800 amperes at 15,000 volts. In the larger sizes the housings are usually of reinforced concrete, and all capacities are designed for use with either solenoid or manually operated oil circuit breakers.

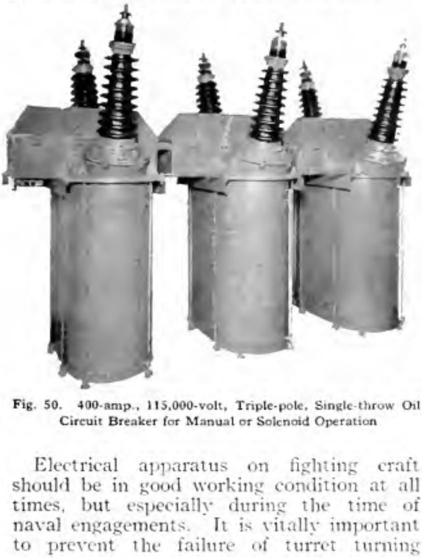


Fig. 50. 400-amp., 115,000-volt, Triple-pole, Single-throw Oil Circuit Breaker for Manual or Solenoid Operation

Electrical apparatus on fighting craft should be in good working condition at all times, but especially during the time of naval engagements. It is vitally important to prevent the failure of turret turning machinery, ammunition [illegible] of the auxiliary apparatus [illegible] controlling circuit. Although [illegible] power or light might [illegible] shocks to which naval craft are [illegible] from the individual or also from [illegible]

Fig. 51. Removable Truck Safety First Switchboard

guns or from a hit by the enemy often make it extremely difficult to keep the electrical circuits in operation.

To help safeguard against this condition shock-proof air circuit breakers were developed (Figs. 54 and 54-A) which will not open accidentally even when subjected to shocks of extremely heavy character.

This has not been an easy task.

The ordinary form of air circuit breaker is held in the closed position by a latch which is released to allow the breaker to open when the armature of the overload magnet moves a certain distance towards the magnet, on the occurrence of a certain predetermined current for which the breaker is set. However, if the breaker is subjected to jar or heavy vibration the armature is in constant motion due to this vibration and the attractive force necessary to pick up the armature is much less. That is, the breaker may trip on a considerably smaller current than that for which it is set to open.

The government specifications limit the temperature rise to 12 deg. C. above the temperature of the surrounding air, which means that for the rating of the breaker considerably more copper must be used than is necessary in the usual construction. Limiting dimensions were also specified by the government.

The problem then was to put more material with increased radiating capacity into a space restricted as to size, and at the same time to make a breaker having a latch which could be tripped only when the overload armature picked up at a predetermined current, without regard to external disturbance, mechanical vibration, or shock.

In the shock-proof breaker the tripping latch is so arranged mechanically that it cannot be moved to the opening position, once the breaker is closed, until the armature of the overload device moves towards its core, and furthermore vibration or shock does not change the magnitude of the attractive force necessary to pick up the armature. The action of the breaker developed to meet these conditions is as follows:

In the interior of a rectangular overload coil (Figs. 54-B and 54-C) is a cylindrical core whose lower end is somewhat below the center of the coil, and beneath the core in the lower part of the coil a movable armature, also cylindrical, is located.

To the lower end of the armature is attached a spring, the tension of which determines the current at which the breaker will trip. The air gap between the core and armature is constant, and the current calibration is obtained by changing the pull of the spring on the armature by means of a knurled nut and calibrating screw at the bottom of the calibrating tube.

In the top of the armature a rod is fastened which projects upward through a longitudinal hole in the core, and carries at the upper end, through a universal joint, the disk of the time delay device, which is enclosed in a covered cylindrical cup containing oil.

Until this device has operated the armature remains stationary, after which the armature rises instantly and trips the breaker. This constitutes a time delay arrangement much favored by the government.

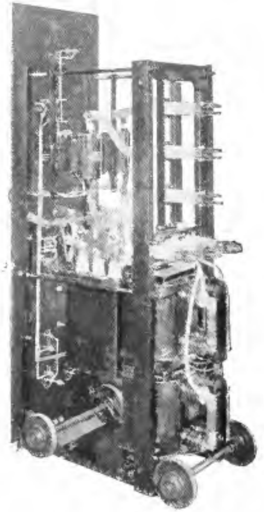


Fig. 52. Removable Truck Panel, Triple-pole, Single-throw, 300 Amps., 7500 Volts

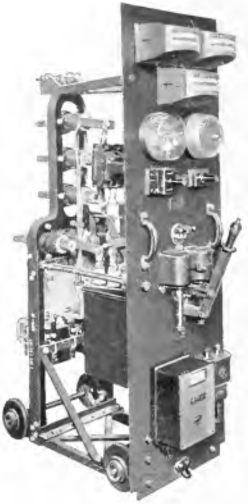


Fig. 53. Removable Truck Panel, Triple-pole, Single-throw, 500 Amps., 2300 Volts

The lower end of the calibrating spring is fastened to a holder through which passes the screw that regulates the pull of the spring on the armature when changing the calibration.

The armature carries a collar having two cylindrical tripping lugs 180 deg. apart, each lug projecting through a vertical slot in the calibrating tube and also through an oblique slot so arranged in a metal piece on each side of the tube as to prevent the movement of these pieces while the armature remains at rest.

Fig. 54. Shock Proof Air Circuit Breaker, Double pole, Single-throw, 100 Amps, 250 Volts

Fig. 54-A. Shock Proof Air Circuit Breaker, Single pole, Single throw, 200 Amps, 250 Volts

The side pieces are pivoted at the lower end, and are moved toward the supporting panel when the armature rises.

On the back of each side piece is a projecting lug which rests over and against another lug on the tripping lever to prevent the movement of the trip latch from the normal position, until released by the backward movement of the side pieces.

When an overload occurs that is equal to or greater than the current for which the breaker is set, the armature rises after the time delay device operates, and the tripping lugs first move the two side pieces to release the end of the trip lever, which is then moved upward to the tripping position by the continued upward movement of the armature. This releases the breaker and allows it to open.

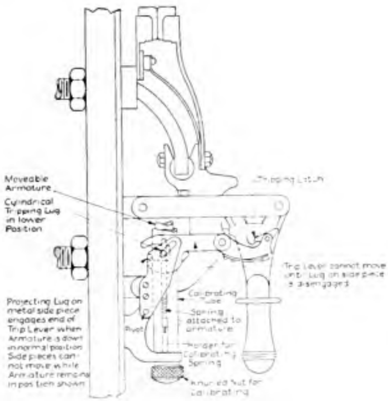


Fig. 54-B. Partial View of Breaker Mechanism showing Breaker Closed

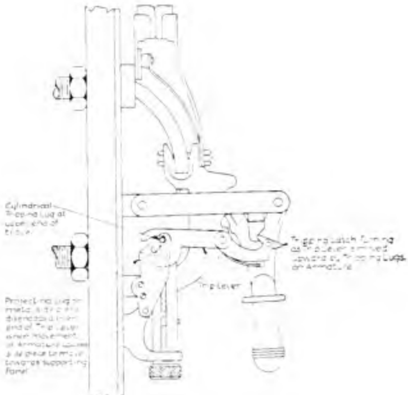


Fig. 54-C Breaker Mechanism, at Instant Armature, has Reached End of Upward Travel

In brief, the breaker cannot jar open because the trip lever is restrained from moving from the normal position by the metal side pieces, which in turn can only be moved by the movement of the armature.

Another interesting feature of these breakers is the manual tripping handle which can be seen in Figs. 54 and 54-A. Because of the time delay device it is necessary to exert considerable pressure at the armature to move it for instantaneous tripping. With an ordinary tripping arrangement having a handle of the length shown this would be practically impossible. This is overcome by the compound lever shown, which allows the breaker to be tripped without difficulty by pressing down on the handle.

Each breaker is tested to insure that it will not trip out on severe shock or on an accumulation of successive small movements of the tripping latch caused by jarring. The method of testing is to mount the breaker on a testing stand, and submit it to shock by the falling of a 38-lb. weight through a vertical distance of four feet while the breaker is carrying approximately the current at which it is set to trip.

Lighting

The total sales of incandescent lamps (excluding miniature) in the United States during 1918 is estimated to be about 175,000,000 lamps (Fig. 55), an increase of 5,000,000 (3 per cent) over the previous year, of which 165,000,000 (94 per cent) were tungsten filament and 10,000,000 (6 per cent) were carbon filament, the latter covering both Gem and carbon lamps.

The sales of tungsten filament lamps increased approximately 17,000,000 lamps (12 per cent) over the previous year, whereas the sales of carbon filament lamps fell off 12,000,000 and were less than half that of the previous year according to estimates. Most of this loss in sales of carbon filament lamps was due to the Gem lamp, which is virtually no longer on the market.

The carbon filament lamp will probably continue to be used for a while in places where its mechanically strong filament makes it desirable when rough usage is unavoidable; but if the mill type Mazda lamp is as successful in service as it has been in laboratory tests, it is expected that the demand for the carbon lamp will eventually disappear.

Of the tungsten filament lamps sold it is estimated that 16 per cent were of the non-vacuum type. On account of their higher price they probably represented 50 per cent of the total value sold. The sales of non-vacuum lamps increased 32 per cent over those of the previous year, and as these lamps are much higher candle-power units and more efficient than the vacuum lamps, the average candle-power of all lamps sold has increased nearly 10 per cent, from 48.7 candle-power in 1917 to about 53.1 candle-power in 1918.

It is interesting to note that just prior to the time (1907) that the Gem and Mazda lamps appeared on the market, when carbon lamps were the only ones available, the average candle-power of all lamps sold was 18, or less than one quarter of what it is today. The average watts of all lamps in 1907 was 53, coming down to 47.4 in 1915, and has now risen, due to the higher wattage non-vacuum lamps, to about 53.8 watts. Thus 11 years ago the average lamp produced less than three tenths of a candle-power for each watt consumed, whereas today the average lamp produces over three times

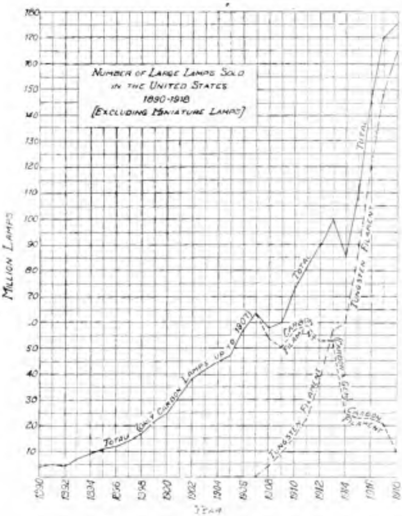


Fig. 55. Chart of Sales of Large Incandescent Lamps

this amount, or nearly one candle-power per watt consumed.

For street lighting more than double the amount of light is now obtained by Mazda lamps when compared with that secured eleven years ago. While in 1907 the average candle-power of incandescent lamps for street lighting was 35 it is now above 70, and if the larger Mazda lamps that have displaced carbon arc lamps are included the average candle-power is above 160.

The sales of tungsten filament miniature lamps increased, it is estimated, from 75,000,000 in 1917 to 80,000,000 in 1918. Practically all these lamps are for automobiles and for portable flashlights used with small dry batteries. A small percentage are Christmas tree lamps and candelabra lamps. Carbon miniature lamps are now practically extinct.

A program for the limitation of the production and distribution of inefficient carbon and Gem lamps was approved by the United States Fuel Administration during the summer of 1918. In general it was recommended that there be a complete abandonment of the installation and renewal of carbon and Gem lamps of all sizes, and discouragement of their use by consumers and the public for any use or application for which tungsten lamps can be substituted, and also that the use of vacuum tungsten lamps in sizes of 100 watts and over be eliminated, and whenever practicable, gas-filled tungsten lamps of the higher efficiency be substituted therefor.*

Fig. 56. Canopy Type Fixture with Short Casing, 10½-in. Band Refractor and Globe

*General Electric Review, Oct. 1918, p. 685.

For country home lighting on storage battery circuit, there are now available standard 28 to 32-volt Mazda lamps in capacities from five to 100 watts.

Fig. 57. Canopy Type Fixture Equipped with Specially Silvered and Coppered Globe

Various Novalux fixtures were improved and new types were developed.

The canopy type fixture (Fig. 56) was produced in order that the 1000-watt Mazda lamp might be used with the Holophane prismatic refractor. This fixture was first installed in the Hog Island shipyard, where it was important that a very large area be illuminated so that night work could be carried on.

Where it was necessary for a large amount of light to be directed on the sides of the boats which were being built, this fixture was equipped with a globe (Fig. 57) that had been silvered and coppered throughout at an angle of 180 degrees and collected the light which would ordinarily be thrown away from the boat and redirected it to the sides of the boat, adding very much to the normal rays of light going in that direction.

The projector type fixture (Fig. 58) has a reflector made of sections of silver-plated glass and is so shaped that it throws all of the light downward in a very narrow beam.

Fig. 58. Projector Type Fixture with Sectional Glass Reflector

Fig. 60. Ornamental Novalux Fixture

Fig. 59. Pendent Type Fixture with Diffusing Globe and Reflector

Fig. 61 R L.M. Standard Dome Reflectors

Fig. 62. Floodlighting Projector Which Will Accommodate the Two Forms of Reflector Shown in Fig. 63

Fig. 63. Two Forms cf Reflector, Either of Which can be Used in the Projector Shown in Fig. 73

It is particularly suitable for the inside of buildings where it is necessary to place the lighting units 10 feet or more above the floor, such as high bays where cranes travel from one end of the room to the other and it is necessary to put the lighting units above these cranes.

The pendent type unit (Fig. 59) can be used either on a multiple or series circuit and can be furnished with or without compensators, which makes it possible to use either low current or high current incandescent lamps. It is possible to equip this fixture with either a large diffusing globe, small diffusing globe, bowl, band, dome, or skirted refractor, and it can be used with or without a reflector.

Fig. 64. Combined Pendent Unit and Projector Mounted on a Simple Bracket

In the ornamental unit [illegible] a diffusing globe (Fig. 60) the [illegible] globe, and canopy have been designed to harmonize so as to produce the [illegible] effect compatible with high efficiency.

Fig. 65. Automatic Protective Cutout

In Fig. 64 there is shown a very simple bracket which was designed for the purpose of supporting both the pendent Novalux unit and the floodlighting projector. Such combinations are used where there are large areas to be lighted, such as shipyards, railroad transfer stations, etc.

One of the devices (Fig. 65) which will be of considerable value to central stations, is intended to prevent the Mazda C lamp from burning out when operating on a direct-current series circuit. These protective devices are assembled in the upper part of the street system bracket and are so connected in the circuit that when the current increases above a fixed amount the lamp is short-circuited and remains so until the current becomes normal again.

The housing shown in Fig. 62 will accommodate the two different shaped reflectors shown in Fig. 63. One of these reflectors gives a spread of beam of between 20 deg. and 30 deg. and the other between 14 deg. and 20 deg.

It has in the past been the practice to substitute Mazda C lamps for Mazda B, using the same accessories. Through illuminating engineering investigations, it has been shown that better results can be obtained, particularly in industrial lighting, by the use of reflectors especially designed for Mazda C lamps.

The Mazda C lamp offers certain advantages in regard to the control of light and

Fig. 66. Factory Yard Floodlighted for Protection

has greater need for diffusion. Through the co-operation of the illuminating engineers of the lamp works with the manufacturers of steel reflectors, a type of enameled steel dome reflector was developed, which will be made by all the leading reflector manufacturers. In order to insure high quality, a specification is being issued by the Research Laboratory, and on evidence of compliance, through test and inspection by the Electrical Testing Laboratories, permission will be given to use the trade mark label. These reflectors which are designated as R.L.M. Standard Dome (Fig. 61) bid fair not only to improve the industrial lighting service rendered by the Mazda C lamps, but to raise the standard of industrial lighting generally.

Artificial lighting was probably as much or more affected by the war conditions than any other application of electricity. While reductions occurred in certain fields, the general result was an increased demand for light and lighting devices. So insistent were the demands for lamps and lamp developments, that the lamp works were strained to their utmost to take care of their part in the national emergency, especially in the face of the labor shortage and the difficulty of obtaining high-grade chemicals and other materials.

It was therefore necessary to restrict all development except such as was of immediate importance. Incandescent lamps and similar devices found new and important applications for military and naval use, and much special development was required to meet the government's needs. These included concentrated filament lamps for various classes of projection lighting.

The Fuel Administration instituted lighting restrictions, not only as a direct means of saving fuel, but also to advertise the need of such saving. Electric signs and bright illumination are convincing evidences of prosperity and activity, and their absence was probably the most effective means of securing saving and the discontinuance of unnecessary activities. Manufacturers seem to be more ready to restrict lighting than do merchants.

It was early evident that mistaken applications of the economy were tending to restrict essential production and increase accident hazard. During the fuel shortage in February 1918, the accident insurance companies noted a considerable increase in the number of accidents and ascribed it to insufficient light. However, the importance of good illumination as a means of improving and increasing production is being recognized by the industries as never before.

While the economic relation has been clearly evident to those who have tried it out, exact data have been hard to obtain. A series of tests made in a number of machine shops by the engineers of the Commonwealth Edison Company, in Chicago, showed that raising the illumination from the ordinary standard to about three times that value resulted in an increase in the quantity of production averaging 15 per cent.

Lighting for protection from malicious destruction, which has been increasing in importance ever since the war started (Fig. 66), continued to expand rapidly throughout the year. Last spring the War Department published and distributed a pamphlet warning of the necessity of such precaution and giving instruction for the design and operation of protective lighting.

Illuminating engineers viewed with some alarm a tendency to restrict street lighting as a measure of economy or conservation. Since the essential element of street lighting is protective, any considerable reduction seemed likely to result in an increase of accidents and crime. Fortunately, curtailment was not carried far enough to provide any serious examples in this country.

There have been, for several years, evidences of increasing governmental interest in various phases of lighting regulation. In the industrial field, some states have adopted codes requiring sufficient illumination, without excessive glare, in order to protect employees from unnecessary accident hazard. During the year such codes were adopted by New York and Wisconsin, Pennsylvania and New Jersey having already done so. In Ohio a code is well under way.

The Federal Government adopted a lighting code for arsenals and plants operated by the government. The Advisory Commission of the Council of National Defense took up the question as a war measure and formed a sub-committee to encourage the adoption of industrial lighting codes by the authorities of other states.

While the intensity requirements are of necessity only sufficient to insure reasonably safe conditions, attention is called to the higher intensitive (Figs. 67 and 68) desirable for efficient production.

The specifications of all the codes so far adopted are practically the same, being based on that of the Illuminating Engineering Society. That organization has also prepared a code for the lighting of school buildings, which, when applied after the manner of the industrial lighting codes, will help to conserve the eyesight of future citizens. This is becoming more important on account of the increasing use of school rooms in the evening.

Automobile headlighting engaged the attention of the authorities in New York State. The highway law was amended and specifications for test were adopted.

The problem has been a rather difficult one, since, in the present state of the art, it is impracticable to provide an adequate driving light without subjecting other users of the highway to serious glare. In response to a general demand, an attempt has been made to eliminate the most dangerous conditions.

Fig. 67. Night View in a Spinning Room Showing General Illumination

A unique feature of the New York specifications is that certain limiting features are definitely specified in practical values of light, whereas all previous headlight regulations have been indefinite.

Even though it be found advisable to modify the specifications in some respects, a strict adherence to the methods of specifications is likely to enhance the safety of night travel.

Considerable progress has been made during the year in the application of Mazda lamps to motion-picture projection. Considerable economy, especially as regards current consumption, is being secured in the numerous classes of smaller theaters, and this with at least as good a projection on the screen as formerly. For many conditions a considerable improvement in the picture is also obtained.

The later experiments have resulted in the adoption of a 900-watt, 30-volt lamp, which on alternating-current circuits is operated through a voltage-reducing auto-transformer. Special accessories, consisting of the regulating transformer, spherical mirror, and corrugated condensing lens (Fig. 69) are essential parts of the system, and the results depend to a considerable degree on the excellence of these equipments. Leading projector manufacturers have housings for this service, and an adapter for changing over existing machines is available.

Fig. 68. Illumination of Hog Island Shipbuilding Yard by Floodlighting Projectors

Fig. 69. Motion-picture Lamp and Accessories—Experimental Equipment Showing Mazda C Lamps and Optical Train. In the commercial outfits these parts are concealed from view by the housing

Progress in Illumination*

ABSTRACT OF THE REPORT OF THE COMMITTEE ON PROGRESS, ILLUMINATING ENGINEERING SOCIETY

This abstract is supplementary to the preceding article covering the development in the [illegible] industry during the past year. The advances made in the field of illumination during this period are so thoroughly presented in the full report of the Committee on Progress of the Illuminating Engineering Society, and any creditable abstract would prove to be unwieldly except as a separate article.—Editor.

INTRODUCTION

A review of recorded information regarding sources of light, the lighting industry and other factors germane to illuminating engineering shows that since the last report of this committee there has been progress in spite of the fact that the prosecution of the war absorbed the interest and activities of practically all classes of workers throughout the country. The very necessity of continuous night work in factories, together with the demand for the highest precision and largest output, has shown conclusively the value of lighting conditions, and their effect on manufacture.

Little has been reported of foreign activities and this mostly on the theme of restricted lighting. In view of the fact that some countries like Denmark and Holland have been forced, owing to coal shortage, to come down to the use of candles and oil lamps, this is not surprising. Nevertheless, some research work is apparently still going on in Germany and it is possible that there have been developments of importance, description of which has not been permitted.

The total eclipse of our main source of light was expected to furnish an opportunity for much new information regarding this most vital factor in human existence. There has not as yet been time to publish the analysis of the results of observations but some interesting points have been reported. At Goldendale[1] where the observers of the Lick Observatory were located, the sky was completely covered with clouds all day until just before the eclipse when a rift appeared which opened up so that a very small area of the blue sky free from clouds had the sun at its center exactly at the middle of the total phase. This region cleared not more than a minute before the beginning of totality, and clouds again covered the sun less than a minute after the passing of the shadow. All the instruments and all of the observers were ready and their program went through as planned.

Manufacture

The war caused such a shortage in coal supply that most European countries experienced[2] great difficulties in keeping up the manufacture of gas.

An English inventor[3] has brought out what is called a new gas of low B.t.u., 350 or less, and a considerable agitation as to the merits of his proposals has resulted. He claims the possibility of increasing the efficiency of utilization of the B.t.u., in good quality, clean dry coal from 50 to 83 per cent. Another new development[4] in gas manufacture is the production of gas from straw refuse on the big ranches of northwestern Canada. A retort has been invented for carbonizing straw and other cellulose material, thereby decomposing them into combustible gases, tars, and ammonia. A ton of straw will give between 11,000 and 12,000 cu. ft. of gas of a calorific value of approximately 400 B.t.u. per cubic foot. From every ton of straw there is obtained 6 to 8 gallons of tar and ammoniacal liquor. In the three prairie provinces of Western Canada only, it is said twenty millions tons of straw are available annually which could be used to produce 140,000 million cubic feet of gas.

A new gas burner[5] introduces directly to the inner surface of the inner cone of the Bunsen flame, a secondary supply of heated air independent of that which forms the mixture in the tube. It is claimed that a

* An annual report prepared for the Annual Convention of the Illuminating Engineering Society.

[1] *Science*, July 12, 1918, p. 34.

[2] *Gas Age*, January 1, 1918, p. 5.

[3] *Gas Age*, April 1, 1918, p. 293.

[4] *Gas Jour.*, November 13, 1917, p. 326.

[5] *Gas Jour.*, August 21, 1917, p. 325.

more perfect gas and air mixture is obtained. The use of large gas lamps containing as many as fifteen mantles is increasing.[1] A new system of gas utilization has been developed[2] by an English inventor. He has devised what is called a pressure balance and is said to have obtained a candle-power of from 130 to 150 with a small gas mantle and a consumption of less than 3 cu. ft. per hour.

It is reported[3] that a supply of monazite sand from the Travancore District of India is now being obtained by an American company. Possession of this property before the war by German manufacturers enabled them to figure prominently in the world's supply of thorium for the making of mantles.

Calorific Standards

After a careful study of the tests made by the inspection department, the Gas Commission of Massachusetts has tentatively decided[4] to adopt the French standard, viz., 528 B.t.u. as the calorific standard for gas in Massachusetts. Previous to issuing the order tests were conducted for six months in nineteen gas plants. The question of a universal adoption of 528 B.t.u. as the standard for gas throughout the country has been raised[5] by the United States Fuel Administration. It is pointed out that this would mean the doom of the old open-flat-flame burner, as with the elimination of the candle-power requirements such a standard is ideal for incandescent gas lighting. The purpose of such an order would be to conserve oil. Agitation for a univeral calorific standard and the abolition of the candle-power standard is also being carried on[6] in England.

At the request of the U. S. Ordnance Department the 600 B.t.u. required average in several New Jersey cities was lowered to 570, it being understood that the permit would be maintained[7] as long as the government finds it necessary in order to obtain a sufficient supply of toluol. Similarly[8] at the request of the Federal Government gas companies in the First District of the New York Public Service Commission could elect to operate under a heating standard for the duration of the war and three months thereafter. An interesting fact has been brought out that in New York City only 20 per cent of the gas consumed is used for open-flame lighting purposes. At Minneapolis[9] the Council agreed to a reduction in the candle-power standard from 15 to 10, but no reduction was made in the heating standard. This action is to last for the period of the war or as long as the company is manufacturing toluol for the government.

Acetylene

A great impetus has been given[10] by the war to the use of acetylene for lighting purposes. A large number of tanks containing the compressed gas are being used in portable hospitals and in first aid stations. Acetylene lamps are also being used for signaling purposes on the principle of the heliograph, and the same gas is used for flare lights to illuminate camps, dugouts, trenches, and for directing troops at night along the road. Small portable lamps are being made in large numbers for use in Cuba and other places where the fire regulations are not so strict as in this country. The old Derby wharf light located off the city of Salem, Mass., has been equipped[11] with an improved automatic acetylene apparatus. Six tanks are provided which are automatically cut in, thus requiring attention only once in six months.

INCANDESCENT LAMPS

Manufacture

The fact that tungsten is used not only for incandescent lamps but also in connection with the manufacture of steel makes its availability a matter of considerable interest. This is particularly true since the advent of the war curtailed the communication which formerly permitted the importation of this mineral from any part of the world. According to reports from the U. S. Consul at Canton[12] there is a rapidly growing exportation of wolframite from China. Much of it comes from a district so remote that the ore is carried on human shoulders for a distance of 60 miles, then 80 miles by junks, and from there on by rail. It is also reported[13] that the wolframite deposits recently discovered in Brazil are very rich and their location favorable to exportation.

Further particulars are now available of the process[14] for producing a continuous tungsten crystal as a filament to be used in

[1] *Amer. Gas Eng. Jour.*, February 15, 1918, p. 165.
[2] *Gas Jour.*, September 25, 1917, p. 563.
[3] *Gas Jour.*, November 30, 1917, p. 386.
[4] *Amer. Gas Eng. Jour.*, December 8, 1917, p. 533.
[5] *Gas Age*, June 15, 1918, p. 582.
[6] *Gas Jour.*, June 11, 1918, p. 476.
[7] *Gas Record*, February 13, 1918, p. 91.
[8] *Gas Jour.*, November 27, 1917, p. 423.
[9] *Amer. Gas Eng. Jour.*, July 6, 1918, p. 18.
[10] *Jour. of Acetylene Ltg.*, January, 1918, p. 240.
[11] *Jour. of Acetylene Ltg.*, November, 1917, p. 180.
[12] *Sci. Amer.*, December 1, 1917, p. 401.
[13] *Elec.* (London), November 16, 1917, p. 253.
[14] *Elec. Rev.* (London), December 7, p. 540.

place of the ordinary drawn wire in glow lamps. A drawn tungsten wire which in the initial cold state has a structure made up of parallel fibers begins to recrystallize after a filament is heated to incandescence. When this recrystallization is complete the extensibility and flexibility imparted by the drawing process disappear, making the filament liable to breakage from shocks. It is the purpose of the new process to preserve these properties both in the cold and hot states. The crystallized filament is so malleable that it can be wound around the smallest mandel, and it maintains this property even after burning for an extended period. Tests have shown[1] that these filaments have remained mechanically strong even after 1200 hours burning with no black deposit appearing on the inside of the lamp bulbs. The radiant properties are said to be very much the same as those of pure tungsten wire owing to the small amount of thorium oxide used.

Carbon Lamps

A circumstance which seems unexplainable to the ordinary engineer is the fact that in spite of the cheapness and superiority of the tungsten filament lamps, the use of carbon filament lamps still shows an increase.[2] The Government[3] retained its carbon lamp schedule in the "Standard Specifications" "because these lamps still properly find a considerable application, particularly in service where the renewal cost of tungsten lamps would be excessive on account of an unusual amount of theft or breakage." However, last year[4] carbon lamps represented only 12 per cent of the total sales of incandescent lamps, and the pressure being brought to bear on the saving of energy in all possible directions may have a decided effect[5] in the direction of the use of the more efficient type of lamp.

Properties

An extended investigation has been carried out[6] on the effect of the form of the voltage wave on candle-power, efficiency, and life of tungsten filament lamps operated on alternating current. In order to magnify the effects, 20 and 25-watt lamps were used. At the end of 1000 hours burning the average candle-power of lamps on [illegible] was slightly higher than [illegible] peaked wave. Similar re[illegible] in the efficiency te[illegible]. In the [illegible] excessive breakage occurred [illegible] wave, amounting to nearly [illegible] on the sine wave.

The subject of "over heating" [illegible] temperature and hence the candle-power of tungsten lamps has been studied at [illegible] length in the past. Recently there appeared a report of an investigation[7] on the amount of "overshooting" in current, when metal filament lamps are thrown in circuit. It was found that the initial current does not rise to a value greater than normal proportionate to the ratio of the hot to cold resistance. Various factors decrease the efficiency voltage at the lamp, thereby preventing the current from rising to a high value. The higher wattage lamps do not "overshoot" to so high a percentage above normal as the low-wattage lamps, and the "overshooting" of vacuum lamps is slightly less than that taking place in the gas-filled type. It was found that with the circuit breakers and fuses of proper rating and set correctly, there was no reason for trouble when throwing in a circuit containing gas-filled tungsten lamps.

Tests have been made[8] to determine what conditions favor flickering with a periodically varying source of light, the lowest frequency permissible with modern metal filament lamps, and the greatest voltage variation permissible on either direct-current or alternating-current systems of a frequency too high to produce flickering. The fact that the frequency at which flickering ceases is, over wide limits, proportionate to the logarithm of the intensity of illumination, was confirmed. The permissible voltage variation was found to depend upon the frequency. The lowest frequency at which flickering is avoided was about 30 cycles per second.

ARC LAMPS

Flaming Arc Lamps

The flaming arc lamp which uses calcium fluoride as its extra light-producing constituent has a decidedly yellow appearance. The addition of uranium as an ingredient, together with the calcium fluoride results in a snow white arc which is said to be exceptionally rich in blue and violet rays, and to have considerably more photographic power than an arc in which the rare earth fluorides or titanium oxide is used.[9] This uranium arc

[1] *Zeitz. Ver. Deutch. Ing.*, January 12, 1918, p. 15.
[2] *Elec. Wld.*, November 3, 1917, p. 849.
[3] Circular No. 13, Bureau of Standards, April 13, 1918.
[4] *Elec. Rev.* (U. S.), May 18, 1918, p. 828.
[5] *Elec. Rev.* (U. S.), July 20, 1918, p. 95.
[6] *Elec. Rev.* (U. S.), March 23, 1918, p. 542.
[7] *Elec. Wld.*, March 2, 1918, p. 459.
[8] *Elek. Zeit.*, September 13, 1917, p. 453.
[9] *Elec. Wld.*, November 24, 1917, p. 1002.

has about six times as much ultra-violet radiation as the ordinary iron arc used in medical work, and hence its use for medicinal purposes is suggested. Efforts are continuously being made to extend the sphere of usefulness of the arc lamp. Thus the white flaming arc has been adapted for use in motion-picture projection in those cases where only alternating current is available. A more uniform light distribution is obtained and the noise is much reduced.

Motion Picture

It is claimed[1] that the correct ratio of the diameters of the positive and negative electrodes has an important influence on the steadiness of the arcs used for cinematograph work, and that a ratio of 4 to 1 is right. Further, by putting a second coating of nickel over the copper plating of the negative carbon, all flickering and sputtering can be avoided. As the present vertical arc lamps used in motion-picture projection work were found to be unsatisfactory when used with a new color photography development[2] an improved arc has been worked out for this special purpose. It is a horizontal magnetically controlled arc which is claimed to give approximately one third more light for the same current than standard vertical arcs and may be relied upon for consistency of position of the source.

LAMPS FOR PROJECTION PURPOSES

Flashlights

The extensive use and importance of flashlights is indicated[3] by the demands of the Navy Department, which in a single demand asks for 182,000 dry flashlight batteries and 68,000 flashlights without batteries. The shortage of materials used in dry cells and small accumulators for pocket flash lamps in Germany[4] stimulated the development of the hand-operated magneto. Lamps thus equipped are more expensive than the ordinary type, but of course they do not need the battery charging or replacement. A type weighing only one pound will provide light for three minutes with one release of the spring, which can be wound with a pressure of the thumb. A heavier apparatus, weighing five pounds and requiring both hands to wind the spring, will furnish light for ten minutes on one winding. In these types the armature rotates; in another lighter type the fields rotate. A moderate sized apparatus for use with bicycles weighs three pounds. Evidence of the use of these magnetos is indicated in the report of the finding of one of the lamps and apparatus on a battle field of France.[5]

Automobile Lamps and Headlamps

The extent to which the demand for electrical lighting equipment for automobiles has grown is indicated by the fact[6] that there are said to be in operation at the present time some 4,000,000 pleasure vehicles, a large majority of which have a unit power plant to furnish electrical energy for lighting, starting, and ignition. In order to make the adjustment less difficult it has been suggested[7] that the ideal form of filament for auto headlight lamps would be a duplex helical filament with one helix lying in the focal axis and inside another helix. It is claimed that such a filament would not require so sensitive an adjustment as is now necessary for the best light distribution.

A novel arrangement devised[8] to keep the light from an automobile within legal limits has been described. It consists of an all-metal cellular attachment, containing more than 9000 small metal reflectors. This attachment is put in the upper half of the head lamp behind the regular glass door and is said to deflect those rays which normally rise above the 42-in. level. It is claimed that the device transmits 93 per cent of the lamp's candlepower. The New York State headlight law passed last year demands a light strong enough to reveal objects at a distance of 250 ft. ahead, and that no dangerous or dazzling light when measured 75 ft. or more ahead of the lamp shall, at the left of the axis of the car, rise above a level of 42 in. It has been suggested[9] that a simple way of making an ordinary clear glass headlight conform to this requirement is to adjust the focus of the bulb so as to give a fan-shaped pencil of emitted and reflected rays. Then paint the bulb a solid dark green over that part of it through which would ordinarily go those rays which project into space on the inroad side of the axis. There have also been devised spectacles[10] with the left part of each lens made of colored glass to aid the driver in avoiding the glare caused by approaching undimmed headlights.

[1] *Illum. Eng.* (London), November, 1917, p. 295.
[2] *Moving Picture World*, October 6, 1917, p. 61.
[3] *Elec. Wld.*, June 29, 1918, p. 1401.
[4] *Sci. Amer.*, January 19, 1918, p. 67.
[5] *Elec. Rev.* (London), October 26, 1917, p. 390.
[6] *Elec. Record*, June, 1918, p. 66.
[7] *Elec. Rev.* (U. S.), December 22, 1917, p. 1060.
[8] *Sci. Amer.*, June 29, 1918, p. 583.
[9] *Sci. Amer.*, September 8, 1917, p. 178.
[10] *Sci. Amer.*, April 13, 1918, p. 348.

Mounted on the roof of a limousine type of automobile in such a way that it can be raised or lowered, or rotated two feet above the roof of the car by the chauffeur, a signal light is made up[1] of a lamp and combination of colored glasses. By this means the car can be readily located by its owner when it is in the midst of a crowded group of other cars.

Many times in backing down narrow roads or into garages, it would be helpful to have a light in the rear of the machine. This need has been provided for[2] in a combination searchlight and tail light contained in a compact case, the two parts being independently controlled.

An improved micrometer focusing device permits[3] of the most delicate adjustment of the lamp in an electric headlight of a locomotive. Independent movement vertically, horizontally, and laterally is provided. In a new headlight designed for use on mine locomotives the lamp is fastened to the reflector, and the latter and the lamp socket are flexibly suspended[4] in the casing. This helps in avoiding the effects of vibrations and jars. Another large railroad[5] has started to replace kerosene lamps with electrical lamps for locomotive headlights. About 2500 will be changed at the rate of from 75 to 100 per month.

Signal Lamps

Special lamps for signaling and for lighting equipment have been developed[6] for use on aeroplanes. A telegraphic signal lamp has been devised[7] consisting of a brass anchor light with Fresnel lens and a specially constructed Morse key which is provided with a condenser placed in its supporting base. Many devices have been worked out[8] to warn users of heating devices such as irons, etc., that the current is on. To meet this need a line of receptacles and flush plates has been designed. A standard flush plate is used in which is set a small bull's-eye of ruby glass. Behind the bull's-eye is a receptacle equipped with a 2-candle-power lamp which shines through the glass as long as the current is turned on.

Motion-picture Projection

After considerable experimentation the past year has seen the introduction of the gas-filled tungsten lamp [illegible] motion picture projection. [illegible] that the intrinsic brilliancy [illegible] filament at operating temperature [illegible] about one fourth that of the [illegible] ordinarily used and that the [illegible] densers pick up a very large [illegible] the useful flux of the arc and [illegible] only a very small percentage of that from the filament, it was thought that the use of a tungsten lamp was impracticable in cinematography[9]. These difficulties have been met by the use of a specially designed optical system. The most important part of this system is a condenser which is designed with corrugations like a semaphore or lighthouse lens. It was found possible with this condenser ($2\frac{1}{2}$ by $6\frac{1}{2}$ ft. conjugate foci) to intercept light through a solid angle of 75 degrees instead of 32 degrees available with the ordinary plano condensers. The corrugations also performed the further function of breaking up the image of the filament, thus eliminating streaks and non-uniform illumination on the screen. A further gain in the effective light available was obtained by using a spherical mirror back of the filament, so adjusted that the image of the filament is thrown back on itself in such a way that the images of the segments occupy the space between the segments and thus produce the effect of a solid band of light. The lamp is of the gas-filled type having a specially coiled filament, the coils in four segments lying in one plane. Two sizes are at present available, one of 600-watt capacity, taking 20 amperes at 30 volts, the other of 750-watt capacity, taking 30 amperes at 25 volts. Extreme precautions are necessary with these lamps to keep the current at a constant value since the filament operates normally at a very high temperature which does not allow of much fluctuation if the rated life of 100 hours is to be obtained. These lamps are said to be suitable for use in theaters projecting pictures up to 14 ft. wide and with a throw as far as 80 or 90 ft.

It is claimed[10] that in Germany it has been found possible to make lamps for projection purposes using currents as high as 200 amperes. The difficulty in making air-tight joints where the leading-in wires pass through the stem is said to have been overcome by a special method which, however, is not disclosed. Apparently the lamps are of the same type, using a mirror, as those just described. The efficiency is given as in the neighborhood of 0.25 watts per Hefner candle

[1] *Elec. Record*, January, 1918, p. 43.
[2] *Elec. Record*, June, 1918, p. 37.
[3] *Pop. Sci. Monthly*, April, 1918, p. 579.
[4] *Elec. Record*, July, 1918, p. 33.
[5] *Elec. Rev.* (U. S.), August 18, 1917, p. 283.
[6] *Elec. Wld.*, May 18, 1918, p. 1031.
[7] *Elec. Merchandising*, May, 1918, p. 275.
[8] *Elec. Wld.*, October 6, 1917, p. 696.
[9] GEN. ELEC. REV., December, 1917, p. 979.
See also Trans. I. E. S., June 10, 1918, p. 232.
[10] *Elec.*, April 12, 1918, p. 846.

Miners' Lamps

The U. S. Bureau of Mines has published[1] a pamphlet in which have been compiled the coal mine fatalities in the United States. There is included a list of permissible explosive motors, and lamps, bulbs, glasses, igniters, etc. This supersedes all previous lists dealing with safety lamps of both the electric and flame type.

INFLUENCE OF THE WAR

While on the battle field light in all its various applications is a vital factor (as in signaling through the use of colored flares, rockets, etc.; in specific illumination, as of "No Man's Land" to prevent surprises; in searchlights both to aid in advances and to protect from attacks; in flash lamps for trench and scouting work) and while in the factory there has been a greatly increased use of light, the influence of the war on ordinary domestic lighting was strongly in the direction of curtailment for the purpose of saving fuel.

The high speed night and day work required in munition plants and by those working on war orders emphasized[2] the importance of good lighting. Lack of proper illumination results in accidents, mistakes, waste, and labor limitations. In a powder mill the question of safety is of paramount importance, and special precautions are taken in such places to enclose the units to avoid possible explosion resulting from exposed heated filaments, or arcs in case of bulb breakage. Another aspect of wartime lighting was found in the lighting of the cantonments which sprang up like magic last fall. Here the provision of sufficient illumination to insure cheerfulness had to be combined with adequate shielding to protect the eyes of the men from glare from the lamps. The problem of protective lighting of buildings and roads also required careful consideration.

It is stated[3] that in both the French and Italian armies portable electric light plants were largely used for the lighting of staff quarters. The generator, coupled direct to a gasolene engine and mounted on a wooden platform, is capable of being carried by a couple of soldiers, and, having been transported on a motor truck, can be utilized in about an hour's time after its arrival.

1 *Elec. Rev.* (U. S.), January 19, 1918, p. 137.
2 *Elec. Rev.* (U. S.), January 5, 1918, p. 3.
3 *Elec. Rev.* (London), October 12, 1917, p. 356.
4 *Elec. Wld.*, November 17, 1917, p. 969.
5 *Ibid.*, December 15, 1917, p. 1159.
6 *Elec. Rev.*, (U. S.), January 5, 1918, p. 32.
7 *Elec. Wld.*, January 5, 1918, p. 58.
8 *Elec. Wld.*, April 27, 1918, p. 888.
9 *Elec. Wld.*, July 6, 1918, p. 26, and July 27, 1918, p. 176.
10 *Signs of the Times*, February, 1918, p. 18.

Restricted Lighting

The government followed the lead of foreign countries in endeavoring to save fuel by issuing orders restricting its use for the purpose of maintaining display lighting of all kinds. The first action, taken November 9, 1917, was the restriction of the use of coal for sign lighting to the hours between 7:45 p.m. and 11:00 p.m. with certain exceptions.[4] Experts of the Fuel Administration estimated that 250,000 tons of coal are used each year for display electric lighting and it was hoped much of this could be saved for other uses.

Subsequently[5] there was under consideration by the Fuel Administration a plan for "lightless nights" in which it was proposed to darken all outdoor lighting other than that required for police purposes. This plan was put into effect by an order issued December 14th making Sunday and Thursday nights practically "lightless." This order also provided for the restriction of considerable indoor lighting. Both orders were made inoperative[6] for districts where energy is obtained through water power. On January 2d a still more drastic order[7] by the State Federal Fuel Administrator made the lightless rules apply to every night but Saturday in New York State. However, these orders were suspended[8] April 25th and a new order which was more drastic for the New England and Eastern states than in those states where the fuel transportation problem is not so great, went into effect July 24th.[9] Under this order the use of light generated or produced by the use of coal, gas, oil, or other fuel for illuminated or display advertisements, announcements or signs, or for external ornamentation of any building was to be discontinued on the first four days of each week in the Eastern states and the first two days throughout the remainder of the United States. Street illumination was restricted and the use of light in show windows prohibited from sunrise to sunset of each day of the lightless nights designated in the order. Similar curtailments were made in Michigan;[10] St. Louis, Mo.; Indianapolis, Ind.; Minneapolis, Minn.; Cincinnati, Ohio; and throughout New England.

STREET LIGHTING

Since the introduction of the high-powered, gas-filled tungsten lamp into the field of street lighting, a great many arc lamps have been displaced by them. But that the arc lamp is by no means a back number in this sphere of work is demonstrated by its use in the so-called intensive or ornamental street lighting in the main business streets of large cities.[1] This type of lighting embodying the "city beautiful" plan was initiated in the so-called "Path of Gold" on Market Street in San Francisco, and a similar installation was made at about the same time in Salt Lake City. In last year's report reference was made to plans for the use of this system in the Triangle District of San Francisco and Los Angeles, the latter city introducing the novelty of having two designs of standards alternating with somewhat different silhouettes. Among the other cities in which the pendent type luminous arcs have been installed during the past year may be mentioned Philadelphia, Pa.; Baltimore, Md.; Bridgeport and New Haven, Conn.; Lowell, Cambridge and Salem, Mass., as well as others to be referred to later.

The Bureau of Standards has begun work on an extensive series of measurements[2] designed to provide information to be incorporated in a street-lighting circular to be issued by the Bureau. Among the early features of the work were measurements made on two types of street arc lamps to determine the distribution of light and variation of candle-power and efficiency with current.

OTHER EXTERIOR ILLUMINATION

Data have been given[3] showing the lighthouse equipment of the Great Barrier reef which forms a natural breakwater about 1000 miles long on the eastern coast of Queensland. Flashlight acetylene lamps of the automatic or "unattended" type are used, those of 1500 c-p. being visible for 13 miles, while those of 5000 c-p. can be seen at nearly 26 miles.

What is said to be the most complete and modern wholesale produce market in the country[4] has been completed in Los Angeles, Cal. The lighting is accomplished by means of 36 gas-filled lamps of 300 c-p. each, supported at a height of approximately 30 ft. by a tubular steel post 5 inches in diameter and tapering toward the top and arranged as a flag-staff.

Display Lighting

A good illustration of co-operation between a landscape architect and an illuminating engineer is to be found in [illegible] fountain on a country [illegible] concealed lighting [illegible] in four sets of [illegible] and fall [illegible] and intermediate [illegible] arranged for independent [illegible]

The use of color in flood[illegible] lighting[6] was well illustrated [illegible] lar illumination of the Canadian N[illegible] Exhibition at Toronto. The [illegible] lighted by 16 groups of flood[illegible] nine 200-watt lamps to a group [illegible] around the outer rim of the large [illegible] just below the surface of the water. White, blue, and green lamps were employed. The dome of the horticulture building was lighted by alternate rows of red, white and blue lamps, 212 in all. The grand stand was provided with 40 reflector units of which 24 were stationary and the remainder movable. The reflectors were 28 inches in diameter, carried 1000-watt lamps and were provided with colored glass screens.

Parkways

Statistics have been gathered[7] by the Bureau of Census showing the relative use of different illuminants for park and street lighting during the past ten years. The results are shown in the following table:

Type of Lamp	Per Cent of Total Number		
	Park Lighting	Street Lighting	
	1916	[illegible]	1907
Electric arc	8.5	34.5	34.2
Incandescent electric	80.1	16.3	10.6
Gas	6.2	41.5	45.1
All other	5.3	7.7	10.1

It will be seen that for this type of lighting the use of incandescent lamps has been growing steadily.

The fact that at the 153 safety islands at street intersections in Chicago[8] 270 accidents occurred in one year has led to investigation of causes and a recommended type of standard. Posts should be painted white and surmounted by a red globe. A white globe with a red bulb inside has not proved satisfactory, nor has the two-colored globe, red above and white below to light up the posts. Small white lights in opaque reflectors just below the red signal will furnish the illumination of the post without causing glare in the eyes of drivers.

[1] From data submitted to the Committee on Lighting and Illumination of the American Institute of Electrical Engineers, and used by permission.
[2] *Elec. Eng.*, December, 1917, p. 36.
[3] *Elec.*, April 12, 1918, p. 846.
[4] *Elec. Rev.* (U. S.), June 8, 1918, p. 962.
[5] *Elec. Rev.* (U. S.), March 30, 1918, p. 551.
[6] *Elec. News*, October 1, 1917, p. 56.
[7] *Elec. Wld.*, September 29, 1917, p. 638.
[8] *Municipal Jour.*, March 16, 1918, p. 221.

The use of small farm lighting plants[1] operating on a storage battery is growing.

Floodlighting

A novel method of obtaining the floodlighting of a store building front was worked out[2] in a city where the projection of floodlight across the street is prohibited. An electric sign extending the length of the building was made in the form of a valance and attached to the outer edge of the eaves of the roof. The lower outline of the valance is closely studded with bull's-eyes which project light used for floodlighting in the rear of the sign; 100-watt gas-filled lamps are used as sources.

More attention to detail is being paid in floodlighting installations.[3] This is illustrated in the case of a Western bank lighted by the use of twelve projectors containing six 500-watt and six 750-watt lamps. It was desired to preserve the appearance of the architectural features as seen under noon sunlight, and projectors placed in three horizontal banks were mounted on a building diagonally opposite in such a position and at such a height as to simulate this condition. Another example[4] of floodlighting a large building is that of the administration offices of the Utah University which is rather unique, as educational institutions are not ordinarily so treated. Ten 500-watt projector units are used.

The floodlighting of the traffic officer[5] as he stands at his post on dark and foggy nights has been found so satisfactory in St. Louis that searchlights for this purpose have been installed at five especially dangerous crossings.

A unique application of floodlighting[6] is found in the illumination of an enormous sign made of concrete and built into the side of a hill. One of the numerals in the sign is 70 ft. by 130 ft. (21.3 m. by 39.6 m.). Nine 1000-watt projector units are used, arranged in a horizontal line on a platform supported by two poles.

Protective Lighting

Much attention and study have been given to the subject of protective lighting[7] as many factors of illuminating engineering practice, such as intensity, distribution and glare, have marked significance and their correct coordination is of vital importance in the application of this branch of lighting to industrial activities. It has been pointed out that search-lamp and flood-lamp requirements are different, and that in many instances either or both are used when ordinary reflectors would be sufficient.

To aid in constantly guarding a western dam[8] use has been made of a source consisting of a 14-in. silvered reflector backing a group of ordinary gas mantles. The projector is mounted above an oblong case containing the fuel and pressure tanks and all operating valves. Gasolene is used for fuel and it is claimed the arrangement is easily handled by one man and particularly useful for isolated locations where gas or electricity is not available.

As war conditions continue[9] the importance of protective lighting was more and more appreciated. This was particularly true of power plants, and various methods were employed. A system used by a large plant which supplies power to a lead and zinc mining district leaves the power house itself in total darkness, but all avenues of approach so brilliantly lighted that the unnoticed advent of a nocturnal visitor would be impossible.

The United States War Department has issued a pamphlet on "Protective Lighting" (Document No. 800) in which the need for protection of public works, industrial plants and other property which is vital to the prosecution of the war and to the welfare of the public, is described. The importance of artificial lighting as a means of guarding such property, and methods of making such lighting effective and of insuring continuity of lighting service are described. The material for this pamphlet was prepared by our Committee on War Service.

Sports

In general, use of floodlighting for outdoor sports has become so common[10] that it is something of a novelty to find a place where this method has not been used. In the case of a certain athletic field the cost precluded the adoption of floodlighting. Good results were obtained, however, by using thirteen 1000-watt lamps in angle reflectors on each side of the field, which is approximately 450 ft. long by 270 ft. wide (137.1 m. by 82.2 m.). On one side the lamps were mounted under the edge of the roof of the grandstand.

[1] *Elec. Rev.* (U. S.), December 22, 1917, p. 1078.
[2] *The Dougherty News*, July, 1918, p. 8.
[3] *Jour. of Elec.*, January 1, 1918, p. 37.
[4] *Jour. of Elec.*, March, 15, 1918, p. 294.
[5] *Municipal Jour.*, March 5, 1918, p. 12.
[6] *Elec. Wld.*, September 29, 1917, p. 635.
[7] *Elec. Wld.*, June 15, 1918, p. 1269.
[8] *Pop. Mech.*, December, 1917, p. 894.
[9] *Jour. of Elec.*, December 15, 1917, p. 540.
[10] *Elec. Wld.*, December 22, 1917, p. 1200.

On the other side the [illegible] were supported on a cable carried by three poles. The lamps were all mounted at approximately 45 ft. (13.7 m.) from the ground and spaced about 25 ft. (7.6 m.) apart. The average illumination was 1.55 foot-candles, with a maximum of 4.40 and a minimum of 0.391. In front of the grandstand the average illumination was 2.79 foot-candles.

A case is recorded[1] where threshing was carried on at night with the aid of lamps placed in the barn. A shortage of labor having made it impossible to get help during the day, enough men employed in shops in the daytime were obtained to carry on the work.

Electrical companies and town councils have offered[2] to provide the lighthouses necessary to light the aerial route between Dayton, Ohio; Indianapolis, Indiana, and other cities to be used by the aviation corps of the army. Searchlights will be turned upward each night to guide the aviators in their flights.

INTERIOR ILLUMINATION

Systems

Certain conclusions were reached regarding the relative expense of direct, indirect, and semi-indirect methods of illumination in connection with a series of tests by a foreign engineer to determine the relative costs and merits of gas-filled tungsten incandescent lamps and arc lamps.[3] The tests were made in a room ten meters by six meters, with white ceiling and frieze and gray walls. The watts per lux per square meter of floor area was taken as a basis of comparison. The results indicated that semi-indirect lighting with tungsten lamps is as cheap as, or cheaper than, direct lighting; for equal illumination, indirect lighting is about 20 per cent dearer than direct and 30 per cent dearer than semi-indirect lighting. These results have been criticized by another foreign engineer who claims that indirect is 82½ per cent and semi-indirect 40 per cent dearer than direct lighting where the comparison is made with the most efficient types of reflectors in the three systems, given identical conditions, and as a requirement, the same foot-candle illumination. Reference should be made to the data presented[4] [illegible] portion for general [illegible]. A large number of [illegible] nation [illegible] make [illegible] valuable.

House Lighting

For some time there [illegible] in the better class of new [illegible] center chandelier, but a western builder [illegible] carried this idea still further and [illegible] side lighting brackets, thus [illegible] in the lines of either walls or ceiling. [illegible] of daylight is furnished and at night the [illegible] effect is simulated through the [illegible] portable pedestal lamps giving a totally indirect system of general illumination. Localized lighting is provided by portable table and desk lamps.

Theaters

The growing appreciation of the value of color in creating the right atmosphere in places of amusement is shown in the lighting installation of one of the newest and largest motion-picture theaters in the West.[6] The semi-indirect system is used and each of the massive wrought metal fixtures contains globes of four colors, amber, white, red, and blue. The four circuits are independently controlled and by the use of motor-driven dimmers any desired effect can be secured. Floor lights are used to assist patrons to find their seats. The exterior is floodlighted from concealed sources.

In an extensive report[7] by the Cinema Commission of Enquiry in England it is recommended that there be adequate illumination of the picture houses while the films are being shown and that an illumination of 0.1 foot-candle seems reasonable. It is further recommended that the front seats should be removed to at least 20 ft. from the screen. The growing use of shaded lights placed on the sides of theater chairs[8] to illuminate the steps of aisles indicates the extent to which specialized lighting is being pushed. Formerly this work was done, if at all, by an usher carrying a pocket flash lamp.

Stores

Dissatisfied with the semi-indirect fixtures available, a large department store has had designed[9] and installed a totally indirect system with some novel features. The fixture is made of plaster of paris in the form of an inverted bowl surrounded by a trough-shaped cornice, and the lamps lie in the trough. The

[1] *Elec. Wld.*, December 1, 1917, p. 1072.
[2] *Elec.* (London), November 23, 1917, p. 260.
[3] *Zeits. Ver. Deutsch. Ing.*, July 28, 1917, p. 625.
See also *Science Abstracts B*, October 31, 1917, p. 392.
[4] *Elec. Rev.*, Nov. 24, 1917, p. 891.
[5] *Jour. of Elec.*, March 1, 1918, p. 239.
[6] *Moving Picture World*, December 22, 1917, p. 1798.
[7] *Ill. Eng.* (London), September, 1917, p. 253.
[8] *Moving Picture World*, January 19, 1918, p. 375.
[9] *Jour. of Elec.*, March 1, 1918, p. 225.

dome is filigreed to admit light within it, giving the fixture a transparent appearance of lightness, while the exposed surfaces are a light ivory in color to match the ceilings. Six hundred watts are used in each trough. The bowl is 30 in. across and hung so that its lower edge is 29 in. from the ceiling, which in turn is 21 ft. from the floor. The fixtures are centered in bays 24 ft. by 16 ft. and are used throughout the main floor.

An adaptation of the camouflage idea to show-case illumination is to be found[1] in a device which consists of three parts: (1) a nickel-finished reflector bowl which contains the lamp and acts as a base; (2) a plate glass shelf mounted on the base and adapted to display goods; and (3) an upright card rack for price cards and reading matter. The reflector has a hole in the bottom so that when set on a glass-top show case it illuminates the goods below it and the source of light is not at once apparent.

Industrial Plants

The National Commission for the Prevention of Blindness has issued[2] a publication on eye hazards in industrial occupations which covers an investigation of some seventy plants, embracing many different kinds of industries. A section is devoted to industrial lighting and the "Codes of Lighting Factories and School Buildings," prepared by our Society, as well as the booklet "Light, Its Use and Misuse" are recommended to those seeking manuals of such information. An illumination of the order of four lumens per square foot is advocated as reasonably satisfactory for offices, and tables are given showing the watts per square foot required to yield this illumination both for gas and electric units, assuming various finishes for walls and ceilings.

What is said to be the largest garbage disposal plant in the world has been placed in operation on Staten Island. Special attention has been given[3] to the lighting features. Among the novel problems to be solved was the proper illumination of the interior of the reducers. Two openings with suitable projections were cast in the top of the tanks. These are placed at such an angle that the light entering one is specularly reflected from the surface of the charge to the second opening. A parabolically shaped and polished aluminum reflector is fixed inside one opening with an aperture large enough to permit the closing of the hole by a steam-tight glass plate and gaskets. A low-voltage candle-power automobile headlight lamp, suitably protected, was found to give enough light when inserted through the opening in the reflector. The general lighting of the reducing room is given by 200-watt lamps in steel reflectors producing a specific power consumption of 0.33 watt per square foot of floor area.

Transportation

Almost everyone who has traveled at night has been annoyed at times by light shining into the berth, coming from lamps left lighted to illuminate the aisles. The Pullman Company after considerable experimentation has developed[4] an installation which is expected to be a solution of this problem. The result has been accomplished by using low candle-power tungsten lamps in receptacles placed under the ends of alternate seats and shielded by green glass.

In the lighting of trolley cars the modern reflector method with the units arranged in a single row in the middle of the center deck has met the needs so well that it is being extensively used in new cars[5] and many roads are changing over existing equipment, but there is one bad feature of street and interurban car lighting, much more in evidence in the latter case than in the former, namely, the effect of voltage fluctuations in the lighting circuits. To meet this difficulty a motor-generator set has been developed for use on interurban lines which it is claimed maintains the illumination without appreciable fluctuations and also preserves the continuity and intensity of the light from the headlights. By using a shunt or compensating device similar to those used with arc lamps, it has been found possible[6] to cut down considerably the maintenance cost of lighting in electric railway cars.

FIXTURES

Reflectors

There is a continual increase in the number of semi-indirect fixtures made up of two parts, an upper diffusing and reflecting glass canopy suspended over a diffusing, translucent bowl. These are designed primarily for stores and office buildings. A similar construction, but made entirely of metal, is found in a group of fixtures designed for industrial plants. Then there is an extensive

[1] *Sci. Amer.*, September 29, 1917, p. 223.
[2] *Publication No. 12*, November, 1917, p. 121.
[3] GEN. ELEC. REV., December, 1917, p. 964.
[4] *Ibid.*, February, 1918, p. 77.
[5] GEN. ELEC. REV., February, 1918, p. 124.
[6] *Elec. Rwy. Jour.*, May 18, 1918, p. 978.

intermediate type in which the reflector is of metal and the bowl of glass, and this type is used both in stores and factories. Among the first named[1] is a new unit in which the upper reflector is made with a prismatic under surface, with the purpose of intensifying the light reflected downward. The use of a simple tripod holder permits the mounting of the translucent bowl without the use of holes or supporting rods.

Still another two-piece unit[2] has a very flat, shallow, translucent bowl and an inverted conical shaped reflector. The outside of this reflector is illuminated by light reflected from the bowl, while light is reflected from the interior of the cone to the ceiling which is also lighted by direct rays from the lamp. A variation[3] in this type has its reflector part made in three pieces.

In the list of metal reflectors reference may be made to one in which[4] a porcelain enameled reflecting band is suspended from the upper reflector in such a way as to intercept all light within the angles of 45 and 85 degrees. This light is reflected to the upper reflector of the same material and redirected downward to the working plane. Both parts are supported directly from the socket, but do not touch the lamp. Another fixture of this class[5] uses a double cone-shaped lower part made up of a concentrating direct-lighting reflector below, and above a reflector sending its light to the diffusing upper part of the unit. This fixture is of spun steel finished in white enamel. Special metal reflectors for use in illuminating billboards, wall signs, and advertising display surfaces have been worked out.[6] The reflector is so shaped that it does not require the bending of conduit pipe to get the proper focus. A locking arrangement is also furnished.

Street Lighting

A new street lighting fixture[7] for use with gas-filled tungsten lamps contains, in addition to the usual supporting and connecting devices, a dome refractor of prismatic glass which collects light emitted upwards and redistributes it sideways and out into the street at an angle [illegible] horizontal. The [illegible] clear glass and [illegible] inside the other. The [illegible] on its outer surface [illegible] the outer part has vertical [illegible] on its inner surface. The [illegible] surfaces come close together [illegible] are sealed, leaving the inner and outer surfaces of the complete refractor [illegible] smooth, thus facilitating cleaning. An enclosing globe used with this fixture is clear glass stippled on the inside, thus producing diffusion and reduction in glare without much loss by absorption.

Specially designed for residential and park lighting service is a new ornamental unit which also utilizes the dome-shaped refractor referred to above for collecting and redistributing light emitted upward. A cone-shaped reflector at the bottom reflects light otherwise wasted and adds to the efficiency of the unit. The outer globe is made of stippled glass and consists of eight panels.

An addition[8] to street lighting fixtures is one for the high-current, high-candle-power series incandescent lamps. It is made of cast iron and is suitable either for an auto transformer or film cut-out socket. For the convenience of those having to do with the planning or providing of street lighting, data have been collected[9] showing the characteristics of a large number of standard type electric units, both incandescent and arc.

Public Buildings

One of the recent developments in specialized lighting is that of the aisles of theaters and motion-picture houses.[10] Several styles of units have been designed for this work.

Special seamless and dustless fixtures[11] have been designed for use in hospitals. In these fixtures the canopies are screwed directly on the connecting tubes instead of being held by a collar. The sockets and shade holders, while equipped to take care of ventilation, are covered with a cap which fits snugly to the tube and shuts out dust while permitting of easy cleaning. The glassware used with these fixtures is chosen with particular reference to protection from glare and ease of cleaning. For the operating room the pendent unit consists of an upper reflector and lower bowl made of diffusing glass. The reflector is adjustable up and down, permitting the use of a concentrating effect when desired. A fixture designed especially for operating tables consists[12] of an octagonal

---

[1] *Elec. Record*, January, 1918, p. 33.
[2] *Ibid.*, June, 1918, p. 33.
[3] *Ibid.*, May, 1918, p. 36.
[4] *Sci. Amer.*, December 15, 1917, p. 451.
[5] *Elec. Rec.*, January, 1918, p. 33.
[6] *Elec. Rec.*, June, 1918, p. 30.
[7] *Elec. Rev.* (U. S.), Nov. 3, 1917, p. 784. GEN. ELEC. REV., June, 1918, p. 430.
[8] *Elec. Rev.* (U. S.), January 5, 1918, p. 46.
[9] GEN. ELEC. REV., December, 1917, p. 945.
[10] *Elec. Wld.*, December 1, 1917, p. 1081.
[11] *Elec. News*, November 1, 1917, p. 42. *Elec. Rec.*, January, 1918, p. 34.
[12] *Elec. Eng.*, June, 1918, p. 58.

reflector 6 ft. in diameter, the various sections of which carry tubular single filament incandescent lamps. It is claimed that the reflected light is confined to the top of the table.

Ships

Since the bulkhead or oyster-fitting holder for incandescent lamps was first used on a Cunard liner about the year 1884, little improvement has been made in this class of ship-fitting until recently. The original form was intended for carbon filament lamps. A redesign has been worked out[1] to adapt this fitting for tungsten lamps. Apart from its application on board ship it is claimed that this fitting is well adapted for use in chemical works, mines, and in places where it is important to protect the lamp from injury, mechanical or corrosive.

Glassware

The idea of using the lamp bulb itself to support the reflector is utilized in an English invention.[2] The reflector ring is of glass, silvered and provided with three adjustable copper clips to enable it to be fitted to the bulb. Tests by the National Physical Laboratory in England showed an increase in the light emitted in a direction toward the tip of the lamp, from 4 to 24 candle-power in the case of a 200-volt, 40-watt lamp. The reflector is slipped on before the bulb is put into the socket.

An ornamental device to take the place of a service flag utilizes a flat alabaster globe[3] about 8 in. in diameter and lighted from within. It is mounted on an indestructible wood pulp pedestal with two molded eagles holding it. On one side a 3 by 5 in. service flag is shown on the face of the bowl while extra stars are furnished to be attached as desired.

A combination light and mirror, to be mounted on the front fender of an auto, is designed[4] to save the use of two headlights and a rear light at night, and to provide a mirrorscope for use by day. The lamp is cut in or out of circuit as the mirror is lowered or raised.

The toggle switch has for a number of years been the favorite in England for use where snap switches are employed in this country. The advantages of simple operation and direct indication of being open or closed has led to its introduction[5] here. Manipulation of this type of switch consists merely in the throw of a lever or toggle. In the *up* position the circuit is made, in the *down* position the circuit is open.

A new time switch[6] for turning on or off the lights in electric signs, illuminated billboards or other unattended lights that should burn for a specified time utilizes a weight descending by gravity. Twenty-four hours are consumed in the descent and contacts made at any desired point or points.

PHOTOGRAPHY

Motion Pictures

The use of an image measuring 3/4 by 1 in. has been standard practice in the motion-picture industry for the past ten years.[7] To overcome some of the inherent limitations involved in the use of such a restricted field of operation a new form of film which moves horizontally instead of vertically has been devised and special cameras for its use and projection have been worked out. The new image is 4 in. by 1½ in., and all the advantages of standard films such as tensile strength and the value of standardization in laboratory work, shipping, and handling are retained. The stage director is enabled to use a larger setting and with an area twice that of the ordinary scenery may be covered without reducing the size of the characters. Improvements have also been made[8] in the ordinary type of projection machine for motion pictures, the most striking feature being the lateral projection and a construction such that with a duplex instrument six reels can be taken care of at a single loading, one machine controlling the starting and stopping of the other.

In order to enable the government[9] to study more intelligently some of the phases of shell action, work is being done on a special triplex camera which will take pictures at the rate of 500 per second. The apparatus is a combination of three picture-taking movements each of which photographs at the rate of 160 per second.

PHYSICS

Light Sources

Another analysis has been made[10] of the efficiency of light production in the case of the firefly, taking into account such factors as the efficiency of food intake and its transformation into energy and the efficiency of the

[1] *Elec. Times* (London), February 7, 1918, p. 100.
[2] *Elec. Rev.* (London), December 14, 1917, p. 561.
[3] *Ibid.*, October, 1917, p. 31.
[4] *Ibid.*, July, 1918, p. 32.
[5] *Sci. Amer.*, March 30, 1918, p. 271.
[6] *Ibid.*, February 2, 1918, p. 110.
[7] *Ibid.*, January 26, 1918, p. 85.
[8] *Ibid.*, March 23, 1918, p. 259.
[9] *Moving Picture World*, December 22, 1917, p. 1781.
[10] *Jour. Frank. Inst.*, June, 1918, p. 770.

utilization of this energy. A simple apparatus has been worked out for separating the invisible ultra-violet radiation from that in the visible part of the spectrum using the method suggested by Wood.[1] The apparatus is useful for determining the exact fluorescent colors of various compounds. The efficiency of various light sources is referred to under the heading "Photometry."

Experiments on the action of light on selenium[2] seem to show that the interior of the material is affected as well as the surface, and hence the thickness of the selenium film in a cell is an influential factor in the effect of the light, a question which has been in dispute for some years.

Data have been published[3] on the ultra-violet transmission of clear and cobalt blue glasses and[4] on the transmission of white light by clear water. Confirmation of the assumption[5] that the absorption by the earth's atmosphere of the ultra-violet radiation from the sun is due to ozone in the upper layers, is indicated by some work on this subject.

Daylight Saving

The daylight saving bill was signed by the President, March 19th.[6] It provided for setting all clocks forward an hour on the last Sunday in March and turning them back again the last Sunday in October. Thus the United States identifies itself in this regard with the twelve European countries which have already tried out the plan and have found it successful. In view of the final result it is interesting to note[7] that at a meeting of the American Astronomical Society last August an informal expression of opinion showed 22 against it, 18 for it, and 6 neutral. On the other hand the general medical board of the Council of National Defense[8] at its regular January meeting passed a resolution introducing the plan of daylight saving and agreeing to lend its influence in securing the passage of the law. Efforts were made[9] while the bill was under consideration [illegible] plan extended throughout the [illegible] to create a greater [illegible] daily power and lighting load [illegible] stations. The Executive Committee on Daylight Saving[10] of the United States Chamber of Commerce was [illegible] agreement that daylight saving [illegible] to be a permanent measure to operate through the entire year.

An analysis of data from Public Utilities in the Middle West for the month of April indicated[11] an average reduction in output in kw-hrs. due to the daylight saving of about 5 per cent. In general the reports which have been published[12] showing the effect of daylight saving on the load curves of other central stations in this country note an improvement. In Canada,[13] after two months' operation, a survey revealed little if any change either in the revenue or operating conditions. So popular has the daylight saving scheme proved in England[14] that, upon urgent request, the date for starting was advanced so as to give five weeks more of the extended daylight period. A committee has been appointed to make plans[15] for the adoption of the daylight saving scheme in Hawaii. It is said that sugar planters in some districts have practiced this for some years, the advance in time ranging on various estates from 15 minutes to an hour.

Light Sources

From experiments[16] in crossing the two substances which are responsible for light production in fireflies, it has been deduced that the oxidizable substance, and hence the source of light, is what is called photogenin by one experimenter, or luciferose by another experimenter. How the other substance, photophelein, acts to aid in producing the light is still hypothetical, but it is suggested that it may cause a dispersion of colloidal particles of the photogenin and thereby increase the surface and permit auto-oxidation. Reference to the efficiency of light production by the firefly will be found under the heading "Physics."

Two trees,[17] the wood of which has the property of giving to water a marked fluorescence, have been rediscovered. One is found in Mexico, the other in the Philippines.

A very novel method of producing the so-called "Artificial Daylight" has been suggested[18] and tested by an experimenter who uses an artificial source such as an acetylene flame or a vacuum or gas-filled

[1] GEN. ELEC. REV., October, 1917, p. 817.
[2] *Elec.*, November 2, 1917, p. 146.
[3] *Jour. Frank. Inst.*, July, 1918, p. 111.
[4] GEN. ELEC. REV., August, 1918, p. 577.
[5] *Nature*, October 25, 1917, p. 144.
[6] *Cleveland Plain Dealer*, March 28, 1918, p. 1.
[7] *Science*, November 9, 1917, p. 467.
[8] *Ibid.*, January 25, 1918, p. 87.
[9] *Elec. Rev.* (U. S.), January 19, 1918, p. 116; February 9, p. 236, and April 6, p. 733.
[10] *Elec. Wld.*, April 20, 1918, p. 838.
[11] *Elec. Wld.*, May 11, 1918, p. 972.
[12] *Ibid.*, July 6, 1918, p. 18.
[13] *Elec. News*, July 15, 1918, p. 24.
[14] *Gas Jour.*, Feb. 26, 1918, p. 388.
[15] *Sci. Amer.*, Nov. 3, 1917, p. 325.
[16] *Science*, September 7, 1917, p. 241.
[17] *Pop. Science Monthly*, April, 1918, p. 576.
[18] *Phys. Rev.*, June, 1918, p. 502.

tungsten lamp, and passes the light through two Nicol prisms with a crystalline quartz plate between them. The path of the light is made parallel to the optical axis of the quartz, and the thickness of the latter as well as the angle between the principal planes of the Nicols must be properly chosen.

An extension of the use of radium compounds[1] to illuminate keyholes, clock dials, etc., is found in a set of flat radium-treated disks to be attached to the dials of clocks at the five-minute points. A pair of hands similarly treated makes it possible to tell easily the time in the dark.

Applications

For night flying, navigation lights on the machines themselves have been found indispensable.[2] In the British machines used to defend London against air raids, they are placed on the edge of the lower plane and are under the control of the pilot. They serve as a guide in squadron formation. In some cases variegated colored lights are used for signalling between the units of invading squadrons. For landing, the British home pilots make use of a flare which is used to illuminate the ground below.

There has been no generally recognized "Scale of Seeing" applicable for daylight use by astronomers. In connection with observations on the sun, the desirability of such a standard scale has been apparent,[3] and work on it has been begun.

Of the many uses of artificial light one of the most unique[4] is in connection with the stimulation of plant growth. Recent experiments along this line showed that with a very intense illumination, 700 lumens per square foot, approaching the magnitude of sunlight illumination, the rapidity of the growth and development of the plants experimented with was approximately double. The experiments suggest the possibility of using the idea commercially for the development of flowers such as Easter lilies which are required at a certain time.

The use of electric or other lights as an aid to fish catching[5] is old, but a western hatchery has used them for aids in feeding.

[1] *Pop. Science Monthly*, February, 1918, p. 221.
[2] *Sci. Amer.*, February, 23, 1918, p. 163.
[3] *Sci. Amer. Sup.*, July 6, 1918, p. 9.
[4] GEN. ELEC. REV., March, 1918, p. 232.
[5] *Elec. Rev.* (London), May 3, 1918, p. 424.

Light as an Aid to the Transportation of Material*

By A. L. Powell and R. E. Harrington

Edison Lamp Works, General Electric Company

As a factor in our transportation and industrial problem the authors [illegible] vincing manner the importance of modern methods of illumination as applied to [illegible] warehouses, piers, etc. Time saved in the delivery of [illegible] embargoes and indirectly in increased industrial output.—Editor.

The war has placed exacting demands on industry and the reconstruction period will require great quantities of manufactured products. How can industry proceed if, with the plants producing huge outputs, the products cannot be moved to the places where required? The factor of transportation is of parallel importance to output.

It can easily be shown and has been demonstrated, to our sorrow, that a weakening of this important link in our system seriously impairs the entire industrial organization. If for one reason or another a terminal becomes congested, this is reflected along the whole line back to the producer. Embargoes are put on and the manufacturers are forced to let up on their output. Each plant depends on others for parts and raw materials. It is, therefore, evident that anything which will help our transportation problem is a factor in our industrial program.

The authors believe, and trust that they can prove to you, that proper and adequate lighting does facilitate the movement of material. Modern methods of illuminating warehouses, express and freight stations and piers thus indirectly increase and expedite production.

Speeding of shipment by good lighting is increased through the following direct causes:

(a) Greater actual speed of trucking, etc.
(b) Markings more easily read.

The indirect effects are:

(c) Less mis-sent shipments.
(d) Reduction of spoilage and thefts.
(e) Improved relations with the public.

These are not theoretical statements, but are borne out in practice.

(a) If a pier or freight station is dimly lighted, many portions in deep shadow, truckers must proceed cautiously, watching out for objects lying about on the floor, or they lack the confidence which comes with clear vision. Accident reports reveal that one of the most common causes is stumbling or falling. With poor lighting this hazard is increased. Not only does an accident affect the injured worker, but it has a demoralizing effect on the entire force. Each workman becomes over-cautious and slows down his movements. Proper light, therefore, increases the speed of freight handling.

(b) In sorting freight or express packages or stowing them aboard ship, it is, of course, necessary to read and check the labels or markings. It is self-evident that with plenty of light less time will be spent on this step of the handling. In many stations there are only a few spots where there is enough illumination to read labels, and material actually has to be moved there to be sorted. Certainly this extra handling is not efficient.

(c) Conversation with express officials indicates that one of their serious troubles is mis-sent shipments. Inadequate illumination is an important contributing cause. The reading matter on waybills is often faint or blurred and many packages are badly addressed. The chances for error under poor light are great. Packages sent to the wrong place sometimes never return. Perishable freight is often entirely lost if mis-sent. Occasionally an entire factory is held up awaiting the arrival of goods, the delay in transportation being due to a mis-sent shipment. Beyond the delay and cost of locating mis-sent material, there follows a further load on the transportation system of sending to proper destination.

* Paper presented before the New York Section of the Illuminating Engineering Society, New York; December 12, 1918.

(d) Spoilage of goods is reduced if there are no dark corners in which packages of perishable material become hidden. Again, boxes that have been broken in shipment are readily caught and taken care of before a greater loss is sustained. Breakage is bound to be reduced, for employees will not throw articles about promiscuously if the place is well enough lighted so that they are likely to be seen. Theft is greatly reduced, as the sneak thief would not dare to pry open a bundle and remove part of the goods if the chances of detection were high.

(e) Modern business methods have made it important to please the public. Common carriers desire to have the most cordial relation with shippers. If consignments are delivered promptly in undamaged condition, if the mis-sent shipments are eliminated, then the transportation agents should have the good will of the people.

In spite of all these actual advantages of proper lighting, the subject apparently in many instances has not been given the attention it deserves. It is the purpose of this paper to point out methods through which the desirable results can be attained with minimum expense. It is also hoped that this brief presentation may call the matter forcibly to the attention of some of the officials in charge, that they may see the importance of the subject and give it the attention and study which it deserves.

TABLE A

DATA ON TYPICAL PIERS—METROPOLITAN DISTRICT

	Size Lamps	Hanging Height Feet	Spacing	Watts per sq. ft.	Color		Reflector	Remarks
					Ceiling	Walls		
Case A	100-watt 4-light clusters	15	40 x 50	0.20	dark	dark	dome	Spacing too wide for hanging height. Inefficient lighting units. Illumination results fair.
Case B	250-watt	18	50 x 50	0.10	light	dark	dome	Spacing too wide for hanging height. Results generally poor.
Case C	250-watt	15	30 x 40	0.20	dark	dark	radial wave	Lighting results good.
Case D	400-watt	14	50 x 100	0.08	dark	dark	dome	Spacing too wide for hanging height. Wattage too low. Results poor.
Case E	100- and 150-watt	15	30 x 30	0.16	dark	dark	dome	Conditions generally fair.
Case F	250-watt	20	irregular	0.07	light	light	dome	Spacing too wide for hanging height. Wattage too low. Results poor.
Case G	100- and 200-watt	18	various	0.09	dark	dark	dome	Results poor.
Case H	100- and 200-watt	20	20 x 35	0.18	light	light	dome	Illumination generally satisfactory.
Case I	400-watt	25	80	0.06	white	dark	dome	Spacing too wide for hanging height. Wattage too low. Results poor.
Case J	400-watt	15	50	0.16	white	dark	dome	Spacing too wide for hanging height. Wattage fair. Results fair.
Case K	100-watt	15	various	0.04	dark	dark	dome	Entire system poor.
Case L	100-watt 4-light clusters	15	30 x 60	0.22	dark	dark	dome	Results fair, but spacing too wide.
Case M	150-watt	18	30 x 60	0.08	light	dark	dome	Spacing too wide for hanging height. Wattage too low. Results poor.
Case N	100-watt 4-light clusters	25	40 x 78	0.13	light	light	dome	Inefficient lighting unit. Spacing satisfactory. Lighting results fair.
Case O	250-watt	20	70 x 50	0.07	dark	dark	none	Conditions very bad.

Investigation has been made of a considerable number of buildings of the class under consideration, and this reveals that in general the standards of illumination are far too low for the most economic operation. Not only is insufficient light furnished, but in a great majority of cases antiquated equipment is employed. Obsolete types of incandescent lamps, inefficient carbon arc lamps and open flame gas burners are more prevalent than in almost any other field the authors have investigated. Even where efficient lamps are employed, frequently light is wasted through the absence of proper reflectors. In many cases where reflectors are installed, they have not been well maintained, becoming very dirty, rusted, and in some cases actually falling apart. Incandescent lamps are allowed to burn after becoming badly blackened, and gas mantles which have half broken off are still in service.

It is apparent that the effect of light colored surroundings in increasing the illumination is not fully realized. Ceilings and walls have been allowed to become almost black, reflecting practically nearly [illegible]. A [illegible] paint will [illegible] a great deal [illegible] fall and allow increased [illegible].

In an investigation of [illegible] piers in New York [illegible] artificial lighting data were [illegible] size of the pier, number and [illegible] units, spacing and height of [illegible] ceiling, color of wall and [illegible] traffic, watts per square foot [illegible] artificial lighting condition.

The investigators were experienced illuminating engineers, competent to evaluate the resultant illumination. An analysis of the results showed that 6.2 per cent had good illumination, 51.2 per cent fair illumination, and 42.6 per cent illumination which was entirely inadequate and generally poor. The average watts per square foot of those piers electrically lighted was 0.16, with a maximum of 0.34 and a minimum of 0.05. Very much better illumination results would have been obtained in practically all the cases if the equipment had been well maintained and surroundings given an occa-

TABLE B

DATA ON TYPICAL FREIGHT STATION—METROPOLITAN DISTRICT

	Size Lamps	Hanging Height, Feet	Spacing	Watts per sq. ft.	Color: Ceiling	Color: Walls	Reflector	Condition	Remarks
Case A	25- and 40-watt	12	12 x 17	0.15 ave.	dark	dark	flat	very dirty	Arrangement good. Intensity too low. Poorly maintained, reflector inefficient.
Case B	300-watt	14	22 x 50	0.27	light	medium	radial wave	good	Arrangement satisfactory, adequate intensity, well-maintained, reflector suitable.
Case C	100-watt	12	22 x 35	0.13	light	light	dome	fair	Illumination adequate for the particular conditions of this freight station.
Case D	100-watt	12	25 x 40	0.10	dark	dark	dome	fair	Spacing slightly too great, otherwise acceptable with better maintenance.
Case E	25- and 40-watt	10	——	——	dark	dark	none	poor	No general lighting provided these lamps serving merely as markers.
Case F	60-watt carbon	8	——	——	dark	dark	none	poor	Lamps inefficient, no reflector, arrangement poor
Case G	100- and 200-watt	11	——	0.24 ave.	dark	dark	dome and none	very dirty	No regular arrangement, poorly maintained, effect generally unsatisfactory.
Case H	100-watt	10	20 x 20	0.25	dark	dark	dome	good	Well laid out, good reflectors, results would be better with painting.
Case I	100-watt	9	30 x 35	0.10	dark	light	dome	fair	Spacing too wide, hence intensity low, otherwise satisfactory.
Case J	25- and 40-watt 3-light cluster	10	30 x 35	0.10	light	light	dome	poor	Generally unsuited.

sional coat of whitewash or other light paint. Three and six tenths per cent of the piers had white walls and ceilings, 9.1 per cent light colored, 20 per cent medium colored, 52.8 per cent dark, and 14.5 per cent very dark (almost black) surroundings.

The above data justify the foregoing criticisms. Such conditions would not be tolerated for the handling of materials in ordinary manufacturing plants, and the surprising feature is that it has been possible to get along at all with such poor light.

A few representative installations of tungsten filament lamps are presented in Table A. The figures given, of course, include many other installations.

A similar investigation of some of the larger railway freight stations in the metropolitan district disclosed conditions as outlined in Table B.

General Requirements of Lighting

Enough light must be provided to read markings, labels, and waybills without eyestrain, and to see one's way about the entire area.

If the first requirements are provided for, the safety element would naturally be taken care of. A minimum of one half foot-candle seems desirable in all parts of the station or pier. With this intensity average print can be read for a short period with reasonable ease. The Illuminating Engineering Society's Code of Lighting for Factories, Mills, and Other Work Places, which has been adopted as mandatory in a number of states, provides a minimum intensity of one quarter foot-candle for passageways, aisles, storage spaces, etc. This value takes care of the safety element alone and is not intended to represent the most economical intensity, the code itself recommending that a higher intensity be provided.

In most instances lamps should be hung as high as possible. Properly applied, this does not reduce the average intensity of illumination, in spite of the popular misconception to the contrary. Lamps well up toward the ceiling are not so likely to be broken. In this position they are handled less and reflectors do not become so dirty. Light sources hung low or in the line of view may blind one temporarily and cause him to stumble.

All light sources of an efficient type are too bright to be viewed for any length of time. They require an accessory in the form of a diffusing globe or reflector which, together with proper placement, protects the eyes. In the class of building under consideration it is generally the best practice to utilize open reflectors, in order to get the maximum illumination with the minimum expenditure of energy. The element of decoration or artistic appearance, beyond neatness, is, of course, not an important feature.

A reflector has the further advantage of directing the light efficiently where it is needed, rather than allowing a large portion to escape to the ceiling and walls. A given area can be adequately lighted with from 25 to 50 per cent less power if lamps are equipped with reflectors, rather than used bare.

As pointed out before, it is most desirable to have walls and ceilings light in color. Paint is a wonderful adjunct to the lighting system. Many a poorly lighted room has been made satisfactory by refinishing the interior. This point cannot be emphasized too strongly in these days of coal conservation.

After the system is properly installed, it should not be neglected. It is most necessary to have a careful system of regular maintenance. This feature seems to be generally neglected in freight terminals. Any railroad man certainly knows that his roadbed would not be safe if it were not regularly inspected and kept in first-class condition. A pier would soon fall to pieces if the spiles were not renewed when broken or rotted. On the other hand, lighting equipment is allowed to fall to pieces, lamps to become broken, reflectors rusty, and very little attention is paid. The output of light is decreased considerably, even with a small layer of dust or dirt, yet many installations are in operation where equipment has been neglected for years. Certainly the user is receiving but a very small percentage of the light he is paying for.

Choice of the Size of Lamp

As a general rule, the larger lamps are more efficient and cost less per unit of illumination than small lamps. The fewer the number of outlets, the less the cost of wiring and maintenance. On the other hand, in designing an installation a consideration of this feature alone may make the lighting practically worthless. For example, an area of 4000 square feet is to be lighted. If one quarter watt per square foot is provided, 1000 watts are needed. For ordinary ceiling heights, one 1000-watt lamp would certainly not be the type to employ.

The size of the lamp is controlled primarily by the ceiling height. In other words, lamps hung 20 ft. above the floor on 20 ft. centers give the same results as lamps 10 ft. above the floor on 10 ft. centers. All other items being equal, mind this statement, a 400 watt lamp 20 ft. high would be as effective as four 100-watt lamps 10 ft. high.

Other items to consider are:

(a) Obstructions of various sorts. If material is piled high or if there is much piping, cross beams, etc., it is apparent that dense shadows would be cast by large lamps widely spaced, which could be avoided by using small lamps spaced more closely together.

(b) Character of ceiling, walls, and general surroundings. If these are light in color, reflecting well, then considerable diffuse light is introduced in the illumination. This eliminates shadows and permits wider spacing.

(c) Size of bay. The total area is usually divided into bays by posts or columns and for good appearance, as well as ease of construction; it is desirable to install outlets symmetrically with respect to the bays. This, of course, has a determining effect on the spacing and hence on the size of lamps. This practice is particularly important in warehouses where material is piled or stored in reference to the arrangement of posts.

Choice of a Reflector

The question of decorative appearance is not very important in the class of building under consideration. The object is to get the maximum light on the floor and hence on the material with the least expenditure of energy. An efficient reflector is essential.

In general, glass reflectors are not well suited for this type of interior on account of the likelihood of their being broken. Freight handlers are none too gentle in their methods, and in carrying high pieces, lengths of pipes, etc., no particular pains will be taken to clear the reflector. An efficient steel reflector is generally the solution.

The dome-type reflector gives a greater spread of light than the deep bowl, permitting wide spacing without intervening areas in darkness. This style also gives a higher output.

The chief [illegible] tioned before and the [illegible] should be such that it can be [illegible] Porcelain enamel is [illegible] applied to the steel base [illegible] advantages of glass. [illegible] and water or even a wet [illegible] porcelain as bright [illegible] it to its original efficien[illegible] has become greasy or very [illegible] acid fumes, whereas other [illegible] to deteriorate rapidly if exposed to [illegible] vapors. Being heat resistant, it does not depreciate nor turn yellow with age. It has a high reflecting power.

All enameled surfaces are not equally efficient. Good enameling appears a pure white or possibly a trifle yellow. A thin coating of enamel appears slightly blue, due sometimes to the base metal showing through. Reflectors with a surface having a slight bluish tint are by no means as efficient as those pure white. The enamel should be evenly distributed and there should be no cracks, however small. Moisture will creep through minute cracks and finally attack the base metal. The enamel should not be extremely brittle, as this chips too readily on being struck. In reflectors to be used out of doors, particular attention should be paid to the enameling around the joints, for these are most susceptible to rusting.

The leading manufacturers of industrial lighting reflectors have now standardized on certain shapes, sizes, and quality of reflectors. A constant check is kept on this latter item and a purchaser obtaining a reflector with the label of approval attached need have no hesitancy as to the items outlined above. The standardization referred to marks a big step forward in "Quality Lighting."

Warehouses, Express and Freight Stations

The light should be quite evenly distributed, as labels and markings must be read anywhere about the floor, yet the demands in this respect are by no means as exacting as where close visual work must be carried on. The intensity should be highest near the doorway and down the main aisles, for here is found the densest traffic. To attain an average intensity of at least one foot-candle and not have the minimum appreciably below one fourth foot-candle, specified by the industrial codes, from 0.15 to 0.25 watt per square foot of floor area is advisable. This figure presumes the use of high efficiency lamps and suitable reflectors, and takes into account an average amount of acquired depreciation, which is rather high in the class of building under consideration.

The following general rules on maximum desirable spacing apply:

Ceiling 10 ft. or less	16 ft.
Ceiling 10 to 15 ft.	20 ft.
Ceiling above 15 ft.	30 ft.

Of course, these are subject to more or less variation, depending on the manner in which material is stored.

For long, narrow rooms (less than 30 ft. or approximately one bay wide), one central row of outlets will serve the purpose well. 75-watt tungsten filament gas-filled (Mazda C) lamps in enameled dome reflectors on 15-ft. centers would be a typical installation for a room with a 10-ft. ceiling, whereas 100-watt units on 20-ft. centers could be used if the ceiling were 15 ft.

If the room is wider, it is well to space outlets symmetrically in the bays. For example, a warehouse from 40 to 60 ft. wide should have two rows of lighting units, while one over 60 ft. will probably require three rows.

With ceilings averaging 15 ft., one outlet in the center of each 20-ft. standard bay is excellent practice, as shown in Fig. 2. Where material is piled almost to the ceiling, it is necessary to localize units with reference to the aisles, as pictured in Fig. 3.

For the loading platforms similar units and rules as to spacing apply. A particularly well-lighted platform of this character is shown in Fig. 5. Where units are exposed to the elements, attention must be paid to the weatherproof qualities.

To provide for the lighting of cars which are to be unloaded or loaded, socket receptacles should be installed on the pillars near the track side of the warehouse or station. In some cases these are installed along the track edge of the platform, slightly below the level of the car doors. This practice has certain advantages in that a shorter cord will suffice and the wiring does not interfere with trucking.

Extension cords with suitable sockets and lamps with wire guard should be available for use inside of the cars. The lamp guards can well have a hook arrangement so that the units may be hung from the ceiling rods in the car. A typical layout for a small freight or express shed with loading platform is given in Fig. 1.

Transfer Platforms

Well-lighted transfer platforms promote safety of trucking and facilitate the handling of freight and express between the freight houses and express platforms, and the cars on the outside tracks. Absence of light here is a contributing cause to the placing of freight in the wrong cars, for a great deal of this work is done at night.

These platforms are generally long and narrow, being merely the space between adjacent tracks. Some are covered and others uncovered. For the covered platforms, units should be located midway between supporting posts, or if the posts are very close together, in each second section. If the platforms are uncovered, a central row of posts should be provided which will support weatherproof lighting units on simple bracket arms.

For this work, a relatively flat reflector is most suitable, for not only must there be light on the ground, but also on vertical surfaces, as the freight checkers must compare stub tickets given them in the warehouses, with similar tickets placed on the sides of the cars, for which the freight is intended.

It is difficult to state exactly what size of lamp should be used, as this depends largely on the spacing. 75-watt units on 15-ft. centers, 100-watt units on 20-ft. centers, 150-watt units on 30-ft. centers should prove satisfactory. If, in the case of uncovered

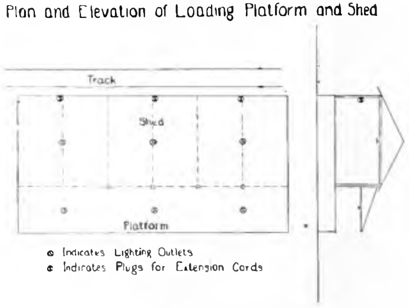


Fig. 1. Diagram Showing Lighting Layout, Typical Small Freight Shed

platforms, the poles are spaced as far apart as 40 ft., it is then well to use two units per pole, one on each side in the plane of the center line of the platform. This is necessary on account of the heavy shadow which would

Fig. 2 Splendidly Illuminated Warehouse of Modern Construction. One 200-watt tungsten filament gas-filled Mazda C lamp in enameled dome reflector is placed close to the 15 ft. ceiling in each 20 ft. bay

Fig. 3. Day View in a Warehouse Which Has an Excellent Illumination System. The rooms are divided into [illegible] by [illegible] on centers 20 by 20 ft. Each bay is provided with two outlets. Sixty-watt tungsten filament gas-filled Mazda [illegible] in deep bowl intensive aluminum finish reflectors are placed close to the 13 ft. ceiling. All wiring is [illegible] conduit and rows of lights are controlled by snap switches, which are located in the [illegible] shown on the columns in the foreground

otherwise be cast by the pole. Whatever unit is used, it should be supported rigidly to prevent its swinging in the wind. It is also well to provide receptacles for extension cords in weatherproof boxes on the pillars.

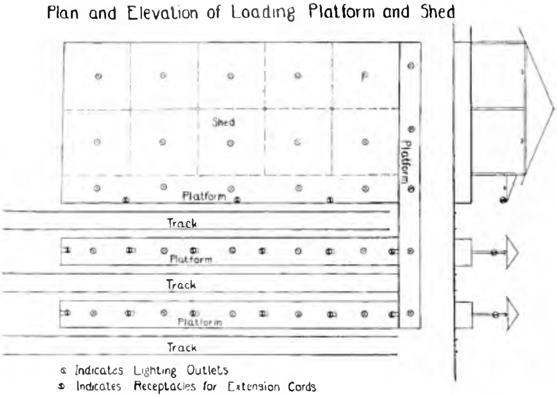


Fig. 4. Diagram of Lighting Layout, Typical Transfer Platforms

A typical series of loading platforms is illustrated in Fig. 4.

Piers

The annual carrying capacity of a vessel depends, to a considerable degree, upon prompt loading and unloading, so that it is good practice to work night and day when it is at dock.

Due to conditions over which man has no control, such as stormy weather, fog, ice floes, and accidents, a fleet of ships cannot maintain any absolutely definite schedule as a railroad, and these unavoidable losses of time must be made up. A good lighting system must be maintained in order that the work may be performed efficiently during the dark hours. With poor lighting, no matter how good the mechanical equipment may be, the human element cannot work rapidly and the docking time will be lengthened. The general effects of good lighting, as outlined in the opening paragraphs, are of course found on the pier and it will speed up the handling of material.

It is further necessary to provide adequate light for the custom officers to properly inspect all freight and baggage in the shortest possible time. The amount of material being handled by the shipping concerns at the present time is greater than ever before, making this subject of vital importance. It is reasonable to estimate that at least one third of the work is done after night time.

There are two general classes of ocean and lake piers, the first, those used for both passenger and freight, the second, those used for the handling of freight only. As a rule the larger piers of the first class are of the double-deck type, passenger section above, while the freight pier is usually only one story in height. Many river piers are similar in structure to railway freight platforms and should be lighted in the same manner.

All piers are long, narrow structures, the sides of which consist of doors through which the freight is passed. The center of the main dock is employed as a driveway for trucks and wagons. Since the freight is loaded from the sides of the piers, more light is required here than over the center, a low intensity sufficing for the trucking. The requirements for the sides of the pier correspond largely with those for a warehouse or freight station. The stevedores must read the addresses and place the hoisting tackle around the boxes, bales, and casks to be loaded. Lamps should be hung high so that they will not interfere with the storage of freight, will not be broken, and so that piles of freight will not cast long shadows. It is often advisable, in the case of a relatively low ceiling to hang lamps between the girders rather than on them. This permits a slightly higher hanging.

For piers handling general freight and merchandise, the rules for spacing and size of lamps given under warehouses apply for the side bays or loading sections: approximately one fourth watt per square foot will give adequate lighting. For the trucking area or center bay, larger lamps can be used on wider spacings. A general figure of one eighth watt per square foot will prove satisfactory. A typical loading platform or side bay well lighted in accordance with the rules laid down is shown in night view, Fig. 5.

Where the pier is relatively narrow with no line of demarcation between the loading areas and the general trucking space, asym-

Fig. 5. Night View of the Delivery Platform of a Large Railroad Pier. This is illuminated by 200-watt bowl-frosted tungsten filament gas-filled Mazda C lamps with dome-shaped enameled steel reflectors, hung well out of reach. Certainly trucking and freight handling can be carried on with expediency under such illumination.

Fig. 6. Night View of the Passenger Section of the Chicago Municipal Pier. This is 2340 feet long. A total of 236 400-watt tungsten filament gas-filled Mazda C lamps in opalescent enclosing globes are hung 25 ft. high. These are on centers 40 by 35 ft. The freight section is located on the floor below. This is of equal dimension but with a somewhat lower ceiling. Similar equipment and spacing are installed.

metrical arrangement of outlets over the entire area best meets the conditions. The diagram, Fig. 7, however, shows an arrangement commonly encountered. For these particular dimensions, 150-watt lamps in enameled dome steel reflectors should be used, one each in the side bays, while 300-watt units of the same character on 50-ft. centers furnish adequate light for the central or trucking space.

For piers devoted to the handling of fruit, the lighting requirements are considerably more exacting. A higher intensity is required and more even distribution. Fruit after being unloaded on the pier is generally sold at auction. The commission merchants visit the piers and inspect the fruit. It is quite important that the true condition of the fruit be shown to the prospective buyer. It is necessary that the color of the fruit is not distorted and a close approximation to white light is desirable for the artificial illumination. A case is on record where commission merchants have refused perfectly good fruit and left it to rot on the hands of the owners, because it appeared green under artificial light, the color composition of which was such as to distort materially the natural appearance. From 0.3 to 0.5 watts per square foot is desirable for a fruit pier.

In the passenger decks of the pier, somewhat more attention should be given to the appearance of the unit. Most people who travel by boat, for business or pleasure, are of a class which are accustomed to the comforts resultant from good artificial illumination. The patronage of this class of people is most desirable in normal times and a well-lighted pier is a factor toward this end. With good lighting the inspection of baggage by the custom officers is facilitated, which tends to eliminate one of the greatest inconveniences of ocean travel. A well-equipped and thoroughly modern passenger deck is pictured in Fig. 6.

The traffic in the neighborhood of a busy pier is quite heavy. To avoid confusion and resultant delay of trucking, the approaches to a busy pier should have somewhat better lighting than normally furnished by the municipal street lamps. Standards are quite out of the question, as they are very likely to be broken by a truck. Brackets suspended from the face of the building provide the logical solution. Standard street lighting equipment of the various types, with their particular advantages, should be used here. The quality of light or the size and spacing of units is a matter that is somewhat out of the province of this paper and governed largely by local conditions. An excellent example of this form of lighting is shown in Fig. 8.

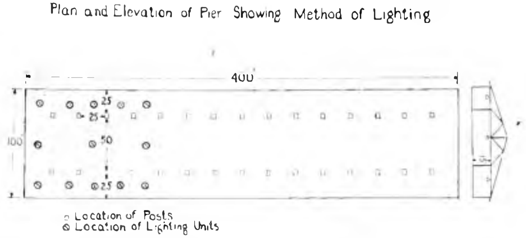


Fig. 7 Diagram Showing Typical Freight Pier Lighting Layout

A completely equipped pier should have high powered lamps on the water side of the structure. These should be hung high so that the open hatchways of the ships will be or can be lighted. This facilitates the freight handling and tends to eliminate accident. The actual lighting of the hatchway itself is taken care of by portable lamps which are part of the ship's equipment. The external lighting of the pier is a great protective agency.

The importance of protective lighting has been emphasized in a number of papers before the Society. Shipping is a very vulnerable part of our war activities. The methods outlined for protective lighting of any building apply equally well to the pier. Lamps suspended from the face of the building in a case of a pier should be supplemented by searchlights and floodlights, which are adjustable and can be used to sweep the surrounding waters. Care must be taken to see that these units are so arranged that approaching and passing pilots are not blinded by glaring beams. Practically all the large piers have this type of equipment now installed. It is inexpedient to go into details as to its construction or application.

Conclusion

It must be borne in mind that a difference exists between freight handling and ordinary manufacturing processes. In the latter, it is possible to install automatic machinery and so plan the work that undue congestion does not result. From the very nature of freight handling, practically all work is manual and rapidity of movement is essential to prevent delays and resultant tying up of traffic. The demand for proper artificial lighting is acute.

While this is true in the case of railroad freight it applies even more forcibly to the ship. If a freight car is held over, only one small unit of a large [illegible]. If a vessel is delayed, entire [illegible] idle, and its crew's wages [illegible] yielding any return.

It is believed that the case for good lighting has been proven. Improper or inadequate illumination increases the cost per ton of handling freight. Since the capacity of a warehouse is dependent on the speed with which material moves through it, bad lighting reduces the capacity. It is certain that it decreases the number of working hours.

Fig. 8. On Account of the Density of Trucking and Traffic in the Neighborhood of a Pier, it is Desirable to Have Good Illumination for all Adjoining Arrears. This night view, taken down the center of the Commonwealth Fish Pier, Boston, shows the effects of using 750-watt tungsten filament gas filled Mazda C lamps in street lighting fixtures of the diffusing type. The lighting units are supported on brackets extending from the face of the building

Conversation with agents in charge of poorly lighted stations and warehouses indicates that they realize that the cause of many mis-sent shipments is lack of proper lighting.

Accidents are increased with darkness. The cost of an accident in damages may be many times the cost of properly lighting a station, warehouse, or pier for a long period.

Methods for More Efficiently Utilizing Our Fuel Resources

PART XXIII. COMPETITION IN COAL MINING AND FULL UTILIZATION OF THE FUEL*

By CHESTER G. GILBERT and JOSEPH E. POGUE

DIVISION OF MINERAL TECHNOLOGY, UNITED STATES NATIONAL MUSEUM

A phase of the fuel situation, hitherto untouched in this series of articles, viz., competition in coal mining, is clearly outlined and emphatically condemned in the following article. Organized and co-operative operation is advocated. The wastefulness of burning raw coal is also condemned, and strong recommendation is made that the coal products industry be expanded to furnish a greater amount of prepared fuel in both solid and gaseous states. The benefits resulting from this improved method of fuel utilization and the marketing of a greatly increased amount of coal by-products are amply described. The authors urge the public to interest itself in bringing this change about.—EDITOR.

In spite of ample supplies in the ground, coal inadequately meets its obligations because of the competitive manner in which it is mined, the unnecessary extent to which it is transported, and the improper way in which it is used. The first has caused tremendous waste, the results of which will be felt heavily in the near future; the second has caused a coal shortage in the present period of stress and promises a repetition at every coming period of sudden industrial expansion; the third has imposed an excessive burden of cost upon the public. To prevent waste, to circumvent shortage, and to lower cost, changes in our system of coal economics are necessary. These changes must be determined by coal itself—by the nature of its geographic distribution, geologic occurrence, mining technology, and chemical composition. It is the purpose of this article to draw from the considerations enumerated—from an analysis of the resource—an expression of the directions which these changes should take.

The Economic Status of the Coal Mining Industry

The United States in 1917 produced in round numbers 640,000,000 tons of coal. About one seventh of this, or 90,000,000 tons, was anthracite, while the rest was bituminous coal of various grades. The anthracite came from a small area of less than 500 square miles in Pennsylvania; the bituminous supply, from 30 states, with Pennsylvania, West Virginia, Illinois, and Ohio contributing about three fourths of the total.

While the greatest improvements, with most telling consequences, are possible and necessary in the utilization of coal, the conditions of coal production are likewise not best adapted to the nature of the resource, and offer opportunities for advantageous changes. Passing over anthracite, because it is not inherently a necessity and because, moreover, its production is effective both as to engineering practice and co-ordination of operations, we find that the mining of bituminous coal is so widely scattered and loosely co-operative that the aggregated activities are to be looked upon as an "industry" only in respect to their common purpose.† The country's most basic resource, indeed, is produced through the medium of a thousand disintegrated units, working without concert and under conditions of destructive competition.

Bituminous coal mining as an industry is beset by conditions which are the occasion of present wastefulness and the justification of apprehension for the future. Scattered and unorganized, most of the individual companies are small and financially weak; no adequate co-operation in engineering practice exists; new developments are slow of growth; coal is mined for the most part by conservative, long-established practice. With no methods of storage developed, the average mine can mine coal only when railroad cars stand ready to receive it; a fluctuating demand, accentuated by seasonal variations, leads to instability of operations; many mines in normal times must close down in slack periods, with destructive effect upon the conditions and supply of labor. For years the price of coal at the mine has been from $1 to $1.15 a ton, a figure so low that only the best and most easily obtainable coal could be extracted by the cheapest methods of mining, irrespective of the waste involved;

*Abstract of a paper "Coal, The Resource and Its Full Utilization" by the authors. Bulletin 102, Part 4, United States National Museum.

†The coal industry in its operations is more comparable to the brickmaking industry than, for example, to the iron industry.

the tonnage of thin seam and high cost areas sacrificed in the process amounts to more than half the total coal produced to date. Many districts have been burdened with a leasing system that obligated the company to remove a given tonnage each year, irrespective of market demand or price, with the result that the richest spots were drawn from seam after seam with irretrievable loss to present needs. Miners' unions in general have fixed wages on the basis of thick and easily worked seams, and imposed such severe penalties upon inferior conditions that the operator is precluded from introducing new and improved methods. Upon all this, the policy of the Government, as exemplified in its anti-trust laws, has forbidden combinations and restrained coöperation, with the result that large-scale, standardized operations, a paramount and distinctive American achievement, is practically lacking in the mining of coal.

These conditions are particularly objectionable because they concern a product of fundamental importance. As compared with the iron industry or the copper industry, the coal industry appears in an unfavorable light in production efficiency. The difference is not to be attributed otherwise than to the competitive system of small-unit mining, which has prevailed for coal in this country and indeed been perpetuated, against a natural tendency otherwise, by a public policy hostile to combination.

Coal cannot be mined effectively under the present system. The nature of the resource demands integration. Only by the grace of lavish coal wealth has the United States this long borne the incubus of competition in coal mining. So much is generally recognized, but the means whereby integration may be attained are less apparent. The most practicable path leads toward the enlargement of the public utilities conception to embrace coal.

We may define a public utility as a necessity which does not lend itself to competition. In such a category fall gas, water, and electricity, the telephone service and traction systems of municipalities. In the case of these necessities, public regulation is substituted for the restraining influence of a competition that has been found inexpedient. Coal is a necessity which does not lend itself to competitive mining.

In anthracite is found an interesting spokesman of this principle. The anthracite industry began with many competing units, but the smallness of the field [illegible] efficiency and led to the merger of [illegible] interests in a unified organization. The purpose of the combination, [illegible] results, was twofold, to [illegible] anthracite and to increase the efficiency of mining. The disadvantages of the [illegible] commonly recognized, but not the ad[illegible] of the second, which were equally [illegible]. Through its monopolistic control of [illegible]nized necessity, the combine year [illegible] became a matter of public concern and the government faced two alternatives in meeting the problem thereby raised: it could either recognize a combination in restraint of trade and order its disintegration; or else accept the combination as a procedure essential to the proper handling of the resource, and impose suitable restrictions on the basis that the activity had become automatically a public utility. The first procedure was adopted and the combine was dissolved in so far as its legal existence was concerned; but at bottom the combination persisted, because it was inherent in the nature of anthracite development and could not be legislated out of existence. The alternative chosen by the government was impossible of execution. It is open knowledge that the anthracite companies today operate in concert and fix prices by circular announcements at rates suitable for the effective operation of both high-cost and low-cost mines. As a result, anthracite is mined efficiently in spite of laws opposing the means to that end.

The bituminous industry deals with a necessity that is lending itself less and less to competitive production. Competition is incompatible with economy, because coals expensive to mine cannot compete on a commercial basis with those which may be mined cheaply, and the two, in general, occur in such intimate association that the first, under present conditions, must be sacrificed in order to get the second. If the price is arbitrarily fixed high enough to cover the extraction of high-cost coal, society will pay too much for low-cost coal. If, on the contrary, the price is allowed to seek a natural level, the high-cost coal cannot be extracted and much of it becomes permanently lost. It may be asserted that we should use up the cheaply obtainable coal first and then later, when necessary, turn to the coal more expensive to produce. Such would be advisable, were it not for the fact that the fat and the lean occur intimately mixed, and we cannot later return and glean the unused values. This limitation is set by the geological occurrence of coal and cannot be changed. The only way by which coal can be mined effectively is for the price to be adjusted to the mining costs of each mine, and even to those of different parts of the same mine. Obviously, this would require a pooling of interests—in short, integration.

Bituminous coal, therefore, is a necessity which cannot be produced advantageously under competitive operation. It has become by its very nature a public utility, and its administration as such, with integrated activity, is the only practicable way by which its full service can be secured.

Integrated coal mining, under proper limitations, will reduce waste, stabilize production, adjust supply to demand, lessen transportation, and hold the centers of coal production longer than otherwise in their present spots to the advantage of the present distribution of industrial activities, but cannot be expected to lower the cost of coal to the consumer. For that purpose, far-reaching changes in coal utilization alone will suffice. While the price of coal to the consumer has been too high, the price of coal at the mine has been, in general, too low—so low in fact that it has been a small factor in the ultimate cost to the public. That is evident in the contrast between one dollar and the figure the consumer pays. The price of coal at the mine mouth, however, has been slowly advancing; the upward tendency is natural, and if left to itself will become stronger and stronger as more and more of the easy-to-get coal is mined. At the present moment the price at the mine is too low, because of the apparent abundance of easy-to-get coal; but within a very few years (if not already), with the exhaustion of cheaply mined coal, the mining costs are bound to attain a rank more consequential in effect upon the ultimate price. It is even now very generally conceded that the "day of cheap coal is over." While integrated mining would add slightly to the average ton-cost of coal at the mine, the effect would be to relieve the further upward tendency from the acute increase which present conditions will inevitably create. The result, in fine, will be to prolong to the utmost the period of cheap coal.

The advantages of integration in coal production are well known in other countries. The thin seams of the eastern coal fields of Canada can be worked only under a co-operative system, as pointed out by the Canadian Department of Mines. Belgian mining law imposes the obligation of co-operative measures upon the coal-mining concessionaire. Co-operative coal marketing has been successfully practiced in many parts of the world, notably in Germany and in the Transvaal.

In short, coal as a resource demands co-operative measures of development. This is true of coal in peculiar degree and holds equally for no other resource. The reason is twofold. In the first place, coal deposits do not lend themselves, as do many other types of mineral deposits, to a graded extraction of values according to the strength of economic demand. In the second place, coal as the major source of power is the basis of modern life, and as such imposes upon organized society a direct responsibility to insure its most effective disposition.

UTILIZATION

Coal as now used fulfills three distinct and unrelated functions. It furnishes industrial power, material for the manufacture of coal products, and domestic heat. About two thirds of the coal consumed in the United States goes into the production of power which is divided almost equally between the industries and the transportation systems; about one sixth is used as a raw material for making substances employed industrially, such as metallurgical coke, upon which the iron industry depends, and gas, nitrogen compounds, benzol, tar, and coal-tar products. One sixth approximately is employed for heating homes and other buildings. It will be observed, then, that the combined industrial requirements outweigh the needs of the home five to one.

This threefold function of coal involves the element of competition, which is latent in normal times, but becomes effective in periods of stress. War conditions in America have lately developed in acute form the inevitable consequence of this competitive tendency, a shortage of fuel for domestic heating.* Industrial users of coal are strong and preponderant; they can meet a growing cost by passing it on to the consuming public in the form of higher prices; and in cases of shortage they are normally given precedence in distribution. Domestic users of coal, on the contrary, are scattered and weak; in general they must accept what is left after the wants of industry are satisfied. The

*This shortage, indeed, has been so great as to extend into industry also.

home, therefore, is forced to pay a price developed by the industrial demand, or else, if the price be artificially fixed, suffer more than its relative share of the shortage which the expanded demands of industry create. This condition is not peculiar to the present situation, though never before, of course, so gravely manifest; it is inherent in our present system of fuel utilization, which if unchanged may be expected to display a repetition during every future period of industrial quickening. Moreover, the growth of industrialism, by increasing the industrial consumption in respect to the domestic, will serve to make the danger progressively more serious.

The competitive tendency that now obtains between the three main uses of coal is not justifiable on the basis of the character of coal itself. On the contrary, these functions, at present antagonistic, are fundamentally complementary, and they can be made so in practice to their common advantage, in respect both to yielding cheaper products to all interests as well as to imparting a stability and elasticity to the supply that will better enable it to weather periods of stress. In the ideal utilization of coal, the domestic and products uses will be completely complementary, while the power use will supplement the other two. Each will benefit from the others, and one cannot be adequately developed without the participation of the other two. The means whereby this advantageous co-operation may be effected are feasible and within the reach of an immediate start toward realization.

Even with the utmost accomplishment in the direction of full, co-ordinated utilization of coal, however, there will still remain the dominant claim of power generation, involving by its size an undue tax upon the transportation facilities of the country. This persisting characteristic of present usage, with all its potency for evil consequences, can be alleviated through the development of a power resource more mobile than coal, which will relieve the railroads of part of their coal-hauling responsibility. Such a resource is at hand in the form of hydroelectric power, as yet hardly touched in this country. The adequate development of water power would not only relieve an unnecessary reliance upon our transportation systems, but it would also reduce the power use of coal to a portion more amenable to proper co-ordination with the parts employed for coal products, industries, and the home.

Fuel for Domestic Heating

The point of logical attack upon the coal problem, then, centers in the home, for here lies the greatest weakness in the present system of coal utilization. It is in the home that conditions are the most discomforting in times of stress, that trouble, whether it be of high price or actual shortage, has the least chance of remedy by industrial enterprise.

Approaching the coal problem from the point of view of the domestic user, we find that the homes of the country are insistent upon anthracite, in so far as its use is not precluded by expense or excessive distance from the point of production in Pennsylvania. Thus the entire northeastern part of the country is entirely, and contiguous territory as far west as St. Paul and as far south as Atlanta is partly, dependent upon what is popularly termed hard coal. As is well known, this is due to the twofold fact that anthracite is clean, both in handling and in its smokeless combustion, and its heating effect is uniform and high.

But anthracite is a luxury. It combines refinements of quality with limitations of supply—the characteristics of every luxury. Its cost of production is approximately twice that of bituminous coal;* it emanates from one region only, a district of heavy freights; it has no capability toward yielding by-products to modify its cost; besides, a big fraction of the available supply is already exhausted. Its domestic use may be continued as a luxury, but anthracite must be dismissed as not equal, or adapted, to the task of supplying the American home.

The home, therefore, independently of its wishes in the matter, must turn to bituminous coal for its fuel dependency. There is no alternative. Already this has happened to a partial extent; war conditions have accelerated the change; the future demands it more completely. The advantages of bituminous coal are well known—its relative cheapness, its wide distribution, its ample reserves,† the possibility of improved utilization. But there is one grave objection to the use of bituminous coal—its dirtiness. This is a valid objection. Burned in the raw condition, it gives off dense, black smoke which dirties the home, pollutes the atmosphere, and becomes the implacable enemy of civic betterment as

*Responsible for this is a complicated geological occurrence, involving folded strata, depth, water, and association with thin seams of slate, as contrasted with the average flat, close-to-the-surface beds of bituminous coal.

†Less than one per cent of the bituminous coal of the country has been used.

well as a menace to the health of the city dweller. Such a result cannot be countenanced. It so happens, however, that smoke represents the most concentrated value in bituminous coal. If we can extract this value and use it toward reducing the cost of fuel, at the same time making a smokeless product for heating use, the sole objection will be turned into an advantage, and the domestic fuel problem will be solved.

Artificial Anthracite

In 1915, before the price of coal was enhanced by war conditions, the average value of bituminous coal at the mine was $1.13 a ton. By way of contrast, Table I shows the latent values contained in this quantity of raw coal, giving the figures in round numbers and basing the calculations on prices prevailing in 1915.

TABLE I

BALANCE SHEET SHOWING CONTRAST BETWEEN VALUE OF ONE TON OF BITUMINOUS COAL AT MINE AND VALUE OF PRODUCTS WHICH IT CONTAINS, BASED ON CONDITIONS PREVAILING IN 1915. THE CONTRAST IS GREATER TO DAY

	Value at mine, 1915.	Quantity	Value at point of production, 1915
1 ton (2000 pounds) bituminous coal contains	$1.13	1500 pounds smokeless fuel	*$5.00
		10,000 cubic feet gas, at 90 cents per 1000.	†9.00
		22 lb. ammonium sulphate, at 2.8 cents	0.61
		2½ gallons benzol, at 30 cents	‡0.75
		9 gallons tar, at 2.6 cents	‡0.23
Total	§$1.13		$15.59

*Figure based upon approximate selling price of anthracite.
†Figure based upon average price of city gas.
‡These figures would be much higher if an adequate coal products industry were in existence.
§This figure shows clearly that lowering the cost of production cannot be expected to lower the price of coal. Even if the cost of production were eliminated, the price of coal would merely be a dollar less.

Obviously, there should be a way for the home to get its fuel more cheaply than it has, when a ton of coal worth $1 at the mine contains about $14 worth of commodities useful to society.

One answer to how these values may be got in full from coal lies in the development of artificial anthracite. The accomplishment depends merely upon the establishment of a process which will isolate the solid fuel portion of bituminous coal in the form of a substance equivalent to anthracite, and produce from the remainder a number of products whose value could be made to more than carry the expense of the operation. Nature has pointed the way with natural anthracite, which was originally bituminous coal, but has subsequently, under the stress of geological evolution, lost its volatile portions, forced out by the action of pressure and heat. It is merely a matter of accomplishing a similar result by artificial means, but with the important advantage that while nature dissipated the volatile constituents and produced only one end product, man could catch these values and turn them to his advantage. There are no insuperable difficulties in the way of such an accomplishment. Several processes capable of this attainment are already in course of development, although comparatively little organized research has been directed to the problem. An intensive attack, such as the importance of the matter deserves, would unquestionably yield an entirely satisfactory procedure. The problem, in reality, is rather one of economics than of technology. When the need of artificial anthracite is generally appreciated, a suitable process for its manufacture will be forthcoming.

Granted the necessity for a smokeless fuel other than anthracite and recognizing that it is chemically feasible to make such a product from bituminous coal, we may examine the existing economic practice that bears on this matter, with a view to ascertaining at what place, if any, a process as outlined may be introduced and placed on a working commercial basis.

The Coke Industry

We naturally turn first to the coke industry, for here the greatest progress in coal utilization has been attained, and besides coke has already been used to a limited extent for domestic heating. The coke industry consumes nearly one sixth of our bituminous coal, and has as its immediate purpose the production of coke, a substance required by the iron industry, which absorbs most of the output.*

Coke is made by heating certain classes of bituminous coal at high temperatures, with the production of a hard, porous residue, composed essentially of carbon. Two methods of manufacture are in general commercial use. One employs beehive ovens, so called from the shape of early types; the other makes use of retort ovens, which are usually long and narrow and assembled in batteries. The latter are also appropriately termed by-product ovens.

The beehive oven delivers a product well suited to metallurgical use, but the process is objectionable because of the waste involved. It not only fails to yield the maximum of coke, but it effects no recovery of other valuable constituents. The products lost represent a measurable waste in terms of dollars, but they carry greater significance as being the raw materials upon which could be built an adequate manufacture of fertilizers, dyes, drugs, and explosives.

The by-product oven receives raw bituminous coal and subjects it to destructive distillation. This process consumes none of the coal, but breaks it up into five components—coke, gas, ammonia, benzol, and tar—of which coke is the main product, while the other four are called by-products. About half of the gas produced is used to supply the heat essential to the operation; the by-products are partly or wholly recovered according to the details of the practice. Where the by-products are wholly recovered, no part of the coal is wasted. In round numbers, one ton of bituminous coal yields 1440 lb. of coke, 10,000 cubic feet of gas, 22 lb. of ammonium sulphate, two and one half gallons of crude benzol, and nine gallons of tar. Half of the gas is available for use as fuel or in lighting; the ammonium sulphate is a valuable fertilizer; benzol is an excellent motor fuel, a substitute for gasolene; tar is a waterproofing material used for making roofing and for dressing roads.

These four first-products have an unlimited field of usefulness as such. In addition, three of them represent raw materials upon which important fields of [illegible] industries are dependent and upon which, if [illegible] supplied, new industrial activities of far reaching consequences can be created. The ammonia, recovered as such or sold in the form of ammonium sulphate, forms the basis of modern refrigeration and is used for making explosives and chemicals. Benzol is a mixture of substances, including the [illegible] toluol, which can be made to yield explosives, dyes, drugs, medicines, solvents, photographic developers, and other chemicals. Tar, likewise, yields a ten per cent fraction which may be turned into explosives, disinfectants, dyes, drugs, and other products. Benzol and tar, in short, are the basis of the coal-tar industry, inadequately developed as yet in America an industry which Germany has intensively cultivated to an advantage now well known.

The by-product oven is complicated and costly to install and to operate. Like the beehive oven, its prime purpose is to deliver coke, but it can compete with the beehive only when the by-products can be disposed of with sufficient advantage to cover the greater expense of the by-product practice and contribute a margin of incentive.

The reasons for the lagging growth of by-product coking in America are clear and specific. There has not been a sufficient demand for all five of the products, due to inadequate industrial utilization of gas and the practical lack of a coal tar industry. Our economic adjustment gave a stable demand for only two of the products, coke and ammonia.

The consequences of inadequate coal products development in the United States have been serious, in some respects critical. Here falls entire responsibility for recent shortages in explosives of certain types, as well as in dyestuffs, and a variety of drugs and chemicals; partial responsibility for the high cost and inadequate supply of nitrogen compounds and gasolene; and even a little of the blame for the transportation congestion of 1917 1918, which industrial coal-gas utilization could have alleviated in some measure. These considerations are apart from wasted materials and wasted opportunities. The coal products situation, indeed, represents one of the most complex, subtle, and important problems in the whole field of industry today; and this is true not only in respect to present conditions, but also as regards the trend of future industrial growth to a degree difficult of full appreciation. The failure of

*From one to one and three quarter tons of coke go into the production of one ton of iron, so that the coke industry is essential to the iron industry. Coke also enters into a number of other metallurgical processes.

Great Britain to sense its importance before the outbreak of the European war came desperately near causing her defeat during the first few months of hostilities through a lack of toluol; the situation was saved only by the happy chance that the British gas industry was developed with by-product recovery, and by straining met the emergency. A similar failure on the part of the United States is responsible for some of our recent embarrassments. A failure to remedy the situation will place this country at an unfortunate disadvantage in the future. It seems remarkable that a single, partly developed unit of industry can have such a vital and far-reaching bearing on the well-being of the entire nation, but such is unequivocally true of coal products. That fact cannot be expressed too plainly or in terms too strong.

Having examined the coke industry and observed its main purpose, the production of metallurgical coke, and the incidental recovery of by-products on the part of nearly half of the activity, we may ask if this industry cannot extend its scope so as to produce a surplus of coke which may be applied to fuel use. The answer is in the negative. Coke, being designed for another purpose, is not a satisfactory fuel. While smokeless in combustion, its cellular structure gives it an intensity of combustion and susceptibility to chill that renders its control troublesome. Even a radical change in furnace design cannot be expected to overcome this difficulty. Moreover, the coke industry is centralized, subject to marked fluctuations according to the demand for iron, and has not yet succeeded in modernizing more than half of its practice. Besides, its by-product manufacture is complicated and costly. Metallurgical coke, then, must be dismissed as an impracticable general-service fuel. The by-product coking practice, however, illustrates the principle of full coal-value utilization and therefore points the way towards progress in respect to fuel coal. Modified by-product plants, simpler than by-product coke ovens, producing a non-cellular carbonized residue and located near the points of utilization, represent the lesson to be drawn from the coke industry.

The Gas Industry

We may turn next to the gas industry to ascertain if this activity is capable of adaptation so as to contribute an adequate smokeless fuel for domestic and power consumption. This industry consists of a great number of separate plants, distributed, one or more each, among the cities of the country.* In the aggregate these plants consume about one per cent of the annual coal production of the country. Their prime purpose is to manufacture gas, and this they do without adequate regard to the complete recovery of by-products, although many plants effect a partial recovery of ammonia and tar, and some gas-house coke is put upon the market. Apart from the oil gas plants on the Pacific coast, in which petroleum is used because of its relative cheapness in that region, the gas industry of the country employs coal as its raw material.

Three types of gas made from coal are in general use—coal gas, carbureted water gas, and mixed gas. Coal gas is distilled from bituminous coal by heating the latter in retorts. Carbureted water gas is produced as a result of the action of steam upon coke or anthracite, the nonilluminating water gas thus produced being then "carbureted," or enriched, by the addition of a gas of high thermal and illuminating power made from oil. Mixed gas is a mixture of coal gas and carbureted water gas and is supplied in many cities in the United States, the coke from the coal gas production furnishing the basis of the water gas manufacture.

Although the municipal gas plant now meets rather inadequately only a small share of the fuel needs of the community which it serves, it represents an established activity which can be converted into an organization that will supply all the fuel, whether gaseous or solid, that the community consumes. The transformation may retain the gas mains and much of the other equipment of the present type of plant, but in the place of the present procedure with relative neglect of by-product recovery will be substituted a by-product system of coal distillation, producing artificial anthracite, gas, ammonia, benzol, and tar. This will mean in each city a centralized purchase and consumption of raw coal, and a centralized distribution of products. The output will be limited at first, at least, by the demand for solid fuel. A production of ample solid fuel will give an excess of gas over that now produced, which will call for an expansion in the use of gas both in the home and in industry. Such expansion will come as a result of cheaper gas, incidental to the proposed plan of production,

*There are over 900 artificial-gas plants in the United States exclusive of by-product coke ovens.

together with improvement in method of utilization; and this very expansion will cut down the use of solid fuel and thereby hasten the adjustment. The three remaining by-products, ammonia, benzol, and tar, as already pointed out, have an unlimited field of usefulness as such, even within the municipality,* and by shipment will contribute a supply of raw material to the needs of the coal products industry, thus permitting and inducing this important field of endeavor to advance beyond the limits now imposed upon it by the coke industry.

The objection may be advanced that artificial anthracite has not been perfected and placed on a commercial basis, and until such time the utilization as outlined above must wait. It is indeed true that such a process is not worked out in detail and ready to be fitted into the present gas industry, but a similar condition has been a stage in the development of practically every technological process and the recognition of the demand has created the means for its accomplishment. But even granting the objection as valid, we find that the production of artificial anthracite is only one of two solutions to the problem of developing an adequate smokeless fuel from bituminous coal. The prime idea is to separate the heat- or energy-producing portion of the coal from the constituents valuable as commodities, and dispose of the two groups to their mutual advantage. Hence if we convert the energy component entirely into gas and recover the by-products, we may accomplish our purpose without calling into service a single procedure which is not already in successful practice in other fields of industry. The municipal gas plant affords, in the second instance also, the locigal point of attachment for the development. Only, in this event, in the place of artificial anthracite and gas, plus ammonia, benzol, and tar, the output would be gas entirely, with a similar production of ammonia, benzol, and tar.

The twofold possibility of advance in coal utilization brings up the relative advantage of a solid, smokeless fuel versus a gaseous fuel. Their applicability for domestic use may be examined first. Solid fuel, such as artificial anthracite, requires no change in present types of furnaces and grates; is applicable to suburban and outlying districts not [illegible] or [illegible] always be in demand [illegible] fuel, on the other hand, [illegible] of storage and handling [illegible] through the automatic [illegible] of gas fired furnaces [illegible] losses growing out of ignorance [illegible] connection with present hand [illegible] industrial purposes, gas offers [illegible] advantages, as evidenced by [illegible] industrial use of natural gas in [illegible] where abundance of supply creates [illegible] price.

The successful instigation and operation of either of the two plans proposed will depend upon public initiative and stimulus. Neither plan may be expected to come into action under the influence of private industrial enterprise; a private organization would have no means of getting adequate returns upon the development expenditure since the benefits contemplated would accrue alike to all industrial activities as well as to the public. The first move, therefore, devolves upon the public; or at least, upon organizations representative of the public interest. The accomplishment, however, will call for a more effective administration of public utilities than has obtained in American cities in the past, and this will come only after full public realization that technical affairs must be directed by technical knowledge.

Technical Advances in Coal Utilization in Europe

In Europe, with the necessity for economies in fuel consumption, far greater advances in the utilization of coal have been attained than in the United States. And these advances, it may be observed, are such as to lend the encouragement of successful experience to the changes in coal utilization demanded by the needs of our own situation. The status of the British gas industry has already been adverted to as higher than that of the corresponding activity in the United States; while the by-product coking of coal, as is well known, has been carried further in Germany than elsewhere, resulting in the strong position attained by that country in the manufacture of dyestuffs, chemicals, and explosives. Noteworthy progress abroad centers also around the development and use of producer gas, the briquetting of low-grade coals, and to a limited degree around the manufacture of domestic "coke."

Producer gas is the result of the complete gasification of coal under the action of a mixture of air and steam.† Both high-grade

*Ammonia as a fertilizer, benzol as a motor fuel, and tar as a road dressing.

†It is strictly speaking modified or semi water gas, lower in calorific value than water gas proper which is made by gasifying coke or anthracite under the action of steam.

and low-grade coals may be employed in its manufacture and the gas may be produced with or without the recovery of the by-products, ammonia, benzol, and tar. Most of the foreign by-products producer plants, however, at least before the war, made adequate recovery of the ammonia only. Producer gas is suitable not only for large service stations, but also for small industrial plants and even for marine engines and locomotives. The manufacture of producer gas from coke, peat, lignite, and high-ash mine refuse has become so thoroughly established on the continent as to be a commonplace procedure. The widespread use abroad of the producer gas principle has brought into competition with high-grade coals, used as such, the low-grade coals and coal-like substances needed to supplement a limited fuel supply.

The briquetting of low-grade lignitic coals and coal slack has been successfully practiced in Germany and other European countries for over 30 years, thus, together with the results attained by producer gas, bringing into service types of coal largely unused in the United States. A number of special forms of fuel coke, approximating artificial anthracite, have met with some measure of success, especially in England, where they are sold under the trade names of coalite, charco, coalexid, and others.

As a war measure, the belligerent countries of Europe have been forced to take radical steps in order to insure an advantageous use of their coal resources. The French and Italian governments have assumed complete control of distribution. In May, 1917, the Russian provisional government took over the coal mines of that country for the purpose of controlling distribution and prices. Early in the war, Germany centralized the entire coal industry under government control and a recent report states that the use of raw coal has been forbidden. In England, the coal mines are under full government authority and in addition a board of fuel research has been established which is recognizing both the economic and technological sides of the problem of bettering the service obtained from coal. The steps taken by the United States are well known.

The Possibilties of American Low-grade Coals

In view of the advances in the utilization of low-grade coals abroad, we are led to inquire as to the potentialities of similar coals in the United States, which have heretofore not been called into action because of the prevalence of more desirable grades. Low-rank coals are very abundant in this country as shown by the United States Geological Survey, whose results are summarized and expressed in round numbers on a per capita basis in Table II.

TABLE II

COAL RESERVES OF THE UNITED STATES CALCULATED TO A PER CAPITA BASIS*

	Now Underground	Mined to date
	Tons	*Tons*
Anthracite	190	28
Bituminous coal	15,000	92
Lignitic coals†	20,000	(‡)

*The calculations are made by the writers from data presented by Marius R. Campbell, The Coal Fields of the United States, General Introduction, Prof. Paper 100-A, U. S. Geological Survey, 1917. The figures are given in round numbers based on a population of 100,000,000.

†Includes subbituminous coal, which is between lignite and bituminous coal in quality.

‡Practically untouched.

The deficiency of anthracite and the magnitude of lignitic coals are at once apparent. It has already been shown how the undue dependency on the small and waning anthracite reserve may be relieved by a suitable by-product utilization of bituminous coal. The further application of the same principle would likewise lend significance to our lignitic coals, tending to raise their value from little or nothing to a point justifying their adoption in the place of higher rank coals in those regions, at least, in which lignites alone occur.

Considerable experimental work in this country has already been directed toward making lignites effective sources of heat and power. Because of their high moisture content and tendency to "slack," these coals are not suitable for transportation like ordinary coal. Efforts toward burning them in powdered form, with the effect of gaseous fuel, or of compressing them into briquets have met with some success, but their greatest possibilities are afforded through complete gasification in gas producers, or by carbonization with by-product recovery. The Bureau of Mines has demonstrated in respect to the last that one ton of air-dried lignite may be made to yield 8000 to 10,000 cubic feet of gas, 17 lb. of ammonium sulphate, one gallon of oil, 50 lb. of tar, and one half to two thirds ton of carbon residue convertible into briquets approaching the value of anthracite. Thus may even coals lowest in rank be raised to meet the social needs for smokeless fuel and economy.

SUMMARY

Coal is a resource requisite to the functioning of every other resource. The home, industry, and commerce are entirely dependent upon its adequacy. Coal is the basis of organized life. Other raw materials are merely parts of the social fabric, incidental to it; iron, for example, does not come to the consumer as such; but coal is comfort and energy as well as a commodity to be manufactured. Coal, therefore, in its far-reaching consequences, has assumed a responsibility equalled by no other substance.

Under present conditions, coal fails to measure up to that responsibility. It is wastefully mined, wastefully distributed, and wastefully utilized. It is wastefully mined because of the conditions of competition which society imposes upon its exploitation; it is wastefully distributed as a result of the unnecessary transportation in regions supplied with water power or with coals less desirable than those consumed; it is wastefully used due to the lack of by-product recovery as an accepted economic practice.

The wastes in mining may be decreased through integrated operations, which will obviate the economic necessity for waste. Coal submits itself to integration as a public utility.

The wastes in distribution may be reduced through the development of hydroelectric power, thus relieving coal of unnecessary duties, and by improvements in utilization, thus destroying the over-dependence upon high-grade coals which now necessitates undue haulage.

The wastes in utilization may be done away with by establishing a method of separating the energy-producing constituents of coal from the commodity values and using the products to their common advantage. The most logical point of attack is the municipality, to which may be attached a public utility plant converting raw coal into smokeless fuel—artificial anthracite plus gas, or gas alone—and valuable by-products, ammonia, benzol, and tar. Such a plant would supply the fuel needs of the community and ship the surplus by-products to serve as raw material for a coal products industry, developed thereby to proportions consistent with its importance to social progress.

Integrated mining will lessen the increased costs that will come with the impending extraction of thick-seam and easily obtainable coals.

Reduced coal transportation will remove an unnecessary burden from the railways and prevent the repetition of the congestion difficulties of [illegible] of 1917, 1918.

By-product utilization [illegible] fuel through the advantage [illegible] as of all the value contained [illegible] coal the smoke nuisance [illegible] and out of the growth of a [illegible] industry with ultimate po[illegible] beyond the grasp of the [illegible]

This article does not pretend [illegible] the exact method whereby these [illegible] be attained; the procedure remains to be worked out in detail. Its purpose, however, has been to present a line of attack, drawn up on the basis of the character and extent of the resource, which may be followed to specific advantage. There are no serious technical obstacles in the way; the chief requisite for progress is a popular appreciation of the fact that coal contains greater value than society is getting from it. From this realization will spring a public demand that scientific and technical knowledge be used, not merely in making improvements in the details of present practice but in revising that practice itself and shaping a policy of administration more in keeping with what is known to be the potentiality of coal. "Mankind," writes John Dewey, "so far has been ruled by things and by words, not by thought * * *. If ever we are to be governed by intelligence, not by things and words, science must have something to say about *what* we do and not merely *how* we may do it more easily and economically."

And, in conclusion, it may be asked what are the assets and the liabilities in this business of demanding a full accountability from coal. Here is the balance sheet:

Assets:
- Ample coal resources.
- By-product coke experience.
- Municipal gas plant installations.

Liabilities:
- Tradition.
- Character of the past administration of the average public utility.
- Character of our past conduct of technical matters.

The assets are large, but the liabilities, it must be admitted, have been insistent enough to block progress in the past. Whether they will continue to overbalance the assets will depend upon the course of public opinion. It is up to the man in the streets to determine which shall prevail. A continuation of the present system of coal economics may be justified on the basis of indifference to progress, but not on the basis of ignorance; its unnecessary prolongation should afford a prospect intolerable to the thinking man.

Some Problems in Shipping

By Chas. M. Ripley

Publication Bureau, General Electric Company

The packing and loading of large apparatus for domestic shipment often presents difficulties owing to weight or clearances, and in many cases special cars are necessary. On the other hand, the smaller pieces of apparatus, usually need to be only carefully boxed to insure their safe delivery to any point in the country. With foreign shipments the problem is entirely different. The shipping department must inform itself of the methods of transportation that will be encountered on the journey, and of the climatic conditions of the country to which the apparatus is shipped. This article points out some of the precautions that are necessary to insure the delivery of electrical apparatus in good condition to South American ports, to India, and to the frigid zone; and some of the difficulties that have to be overcome in domestic shipments of large apparatus are also mentioned.—Editor.

Would it occur to you that electrical machinery for the west coast of South America would have to be packed differently from that for the east coast? Nevertheless, experience has shown that entirely different arrangements must be made because of the undeveloped facilities of many of our southern neighbors.

Machines for the west coast must be "dismembered" into numerous small packages of comparatively light weight, because there are no wharves, piers, or docks worthy of mention on the entire west coast. And besides, a burro cannot carry up into the Andes Mountains a package weighing over 170 lbs., while a mule's limit is 350 lbs; so that electrical apparatus must be "knocked down" before being sent on such a long and arduous journey.

Into the Heart of the Andes Mountains

Just think of the preparation necessary to insure safe delivery of electrical machinery to many parts of South America! Transportation is by railroad to New York, by boat to South America, and from the boat into canoes. These canoes are paddled as close as possible to shore, and the boxes or packages of carefully made electrical machinery are tossed into the surf. They are then dragged ashore and trucked to a railroad station, and begin a rail journey of from two to four days, probably on an open or flat car, to the end of the line near the foot of the mountain; then for four days or more in an open boat, rain or shine, with Aztec Indians or peons as pilots. And then after the river ceases to be navigable, the Yankee motors and generators are loaded on the backs of mules for their journey up the narrow winding rocky paths of the Andes Mountains. Do you think that the Aztec Indian is careful to lower the package of precious machinery gently from the mule's back to the ground? Our Indian friend is probably as tired as the mule and merely loosens the strap, allowing the box to fall to the ground, whether it be rocky or marshy, whether the sun be shining or the rain falling.

To appreciate these difficulties, remember that salt water as well as fresh water has been encountered, that the machinery has risen from sea level in a tropic land to the snow-capped mountains of the Andes, and that after arriving at the location of the power house it is likely to be left lying on the mountain side for months before the engineers are ready for it.

But the experts of American industry have learned how to pack the machinery to defy breakage, rain, and moisture; and they can guarantee in advance that the machinery will operate without a hitch.

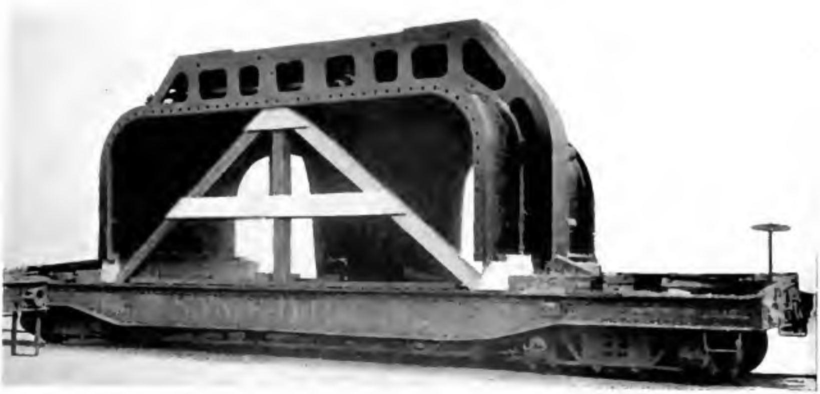
And other problems must be solved, even on the better developed parts of the west coast of South America. In some places the machinery is lowered into lighters to be taken ashore. In spite of its name, the Pacific Ocean has many a rough sea, and you may picture a load of several tons of generators or motors being lowered from the vessel to the lighter, the lighter coming up on the

Typical Packing Case for Export Shipment. Note banding iron, breathing holes protected with wire netting to exclude mice, "Haut Top Arriba" and arrows to indicate top of box, and notched lower corners to accommodate slings

crest of a wave with practically irresistible force. The size and weight of packages must be so limited that the men handling the derricks are able to safely land the machinery in the lighter, and not permit it to go crashing through the bottom into the sea.

Hindu Transportation

In India crude trucks drawn by oxen carry loads as heavy as three to five tons, and the elephant can haul ten tons. In a recent installation of Yankee machinery in India, one year was required to carry the apparatus 250 miles into the interior by elephants. A curious sight was witnessed when the Hindu organized committees of welcome, with bands of native musical instruments, to meet the Yankee engineers; for the story had been spread that the Americans were to introduce that weird God of lightning which would lighten labor and pierce the night of their wilderness country in the Himalaya Mountains.



The Detroit 45,000-kv-a Steam Turbine Generator Required Fifteen Freight Cars for its Shipment. This shows the lower half of the exhaust on one freight car. Note bracing for distributing load

The Termite

In India, just as in South America, the jarring of loading and unloading must be guarded against; but besides this there is in India a different enemy of electrical machinery who is most formidable, although he is only three quarters of an inch long from stem to stern. This enemy is the dreaded termite.

If a box of machinery were left overnight unprotected on a truck, the next morning there would probably be nothing remaining of the entire shipment but the bare metal. The termite is an insect which feeds chiefly on wood and does not leave even as much as sawdust after he has completed his meal. On one occasion a row of telegraph poles was completely eaten up [illegible] and in 48 hours nothing was le[illegible] and the glass insulators.

Engineers have found that coal tar is repulsive to the termite, so that all [illegible] for India are heavily coated with coal tar in much the same fashion as it is spread on the roof of a building.

On this 250-mile journey to the Himalaya Mountains in India, it was found that many of the bridges had to be rebuilt in order to carry the heavy loads, the equal of which had never before passed so deep into the heart of the country.

Cold Climate

Now let us turn from the elephant of India to the dog sleds of Alaska—at almost opposite ends of the earth. Electricity is needed in the frigid zones as well as in the torrid zones, and the dog of the Eskimo is the accepted means of transportation in these northern latitudes. One thousand pounds is the limit in weight of each package in order that it may be effectively handled by a standard dog train. So well does the shipping expert comprehend the peculiar local conditions that special horns are provided on each package to assist the Eskimos in lashing the packages to the sleds. Thus the men of the shipping department must understand the customs and environment of the Hindus in the Himalaya Mountains, the Indians in the Andes Mountains, and the Eskimos in the Yukon District of Alaska.

Large Apparatus

That the development of the art of shipping has kept abreast of the development of the electrical industry itself is very well shown by the following instances.

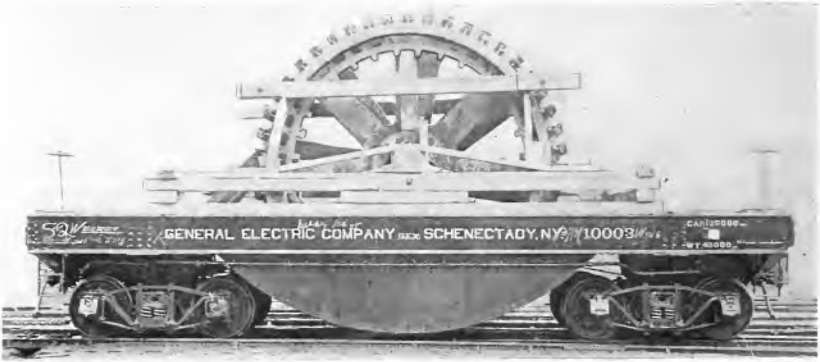
When the first great turbine was built in Schenectady, in 1902, to be shipped to Chicago, it caused great perturbation in the shipping department. Two railroad cars were broken in attempting to load one of the cases; the railroad company deliberated for a week before it could decide whether it could transport the turbine to Chicago, and a special train requiring an extra expense of $1000 in addition to the regular freight charges was necessary to get this piece of apparatus to its destination.

Now we are shipping turbines of 50,000-kw. capacity—over 60,000 h.p.—instead of merely 5000 kw. as a maximum. The shipping experts say that today when a turbine of only 5000 kw. is to be shipped, it is no more of a job than putting it under the arm and carrying it away, figuratively speaking. A 5000-kw. turbine is nowadays only a market basket load. The real interesting problems in shipping arrive in connection with the giants of 50,000 kw.

Special Cars

The Company has arranged for special cars of unusual strength, with increased depth reaching down to within a few inches of the rail, and otherwise adapted for the peculiar variation in size, shape, and weight of modern electrical machinery.

The art of fastening these large pieces of machinery to a freight car has been developed to a high degree of perfection. In a recent wreck on a western railroad the car containing General Electric apparatus was upset; but when the wreck was cleared, it was found that the platform of the car and the apparatus were still integral, the platform having left the trucks but remaining fixed immovable to the apparatus.



Special Freight Car for General Electric Company. Note the small clearance between the bottom and the rail. This is necessary in order that large machines can be shipped as nearly completely assembled as possible, and yet pass under all low bridges and through all tunnels

Some Interesting Figures

Think of making boxes by electricity, and of driving nails by electricity—that is the way they do things in the Shipping Department. Every day they use one and one half tons of nails at the Schenectady Works.

To the layman the fact that 13½ million feet of lumber is used every year does not seem very surprising—few of us remember that a foot of lumber is one foot square and one inch thick; but this amount of wood in boards one inch thick would cover a ranch of 300 acres. Then there is the banding iron which strengthens the boxes: the Shipping Department in Schenectady alone using 690 miles every year. Twenty million sq. ft. of wrapping paper, waterproof paper, and rubber-covered lining was also required for a year's work.

This Department at the Schenectady Works occupies 350,000 feet of floor space distributed over 15 buildings, and employs 693 persons.

Other Problems

Here are some interesting examples of overcoming seeming impossibilities. When the large generators for the Metropolitan Street Railway were to be shipped to New York City, it was found that the loaded car would be one and one half inches too high to clear the bridges. It was therefore necessary to give the springs of the railroad cars a special compression at the factory in order to permit the cars to get through. This heroic method overcame the contention that "It can't be done."

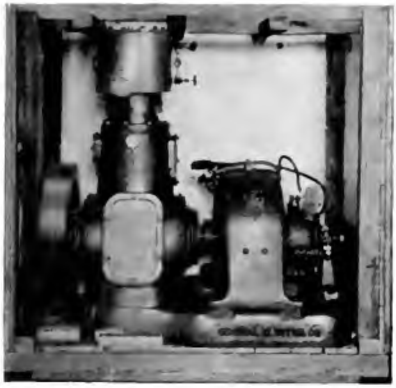
And there are many wonderful stories to be told of single turbines that require 15 separate cars for shipping; of special cars carrying from 50 to 70 tons each; and of how the apparatus has been so nicely poised and balanced on the car that clearance between the sides of the tunnels or bottom of the bridges has been figured out to one half inch. In such nice calculations as these it has been necessary to abandon the use of wood for boxing, substituting sheet metal to obtain a covering thin enough to avoid crashing into bridges or scraping the sides of tunnels in the Rocky Mountains, as either occurrence would probably wreck the entire train.

When some of the big water turbines were to be sent to a power plant in the Rocky Mountains, there was a man in Schenectady who knew of a weak bridge in Minnesota, a low bridge in Montana, and a narrow tunnel in Idaho, and he knew just what the limitations were, and which railroad would be best for the shipment. Some apparatus for New England is shipped by way of Scranton, and taken by water to its final destination, because the railroad facilities of New England are inadequate for such shipments.

But the problems of the American railways are not the only ones which must be solved. The French bridges and tunnels have smaller capacities than ours. Therefore, when large shipments of electrical machinery go to France or South America (for the conditions are the same) the usual method of packing, skidding, etc., must be altered.

An interesting example is the case of the steam turbine generators that were sent to the Tuileries in France. They were packed one way for shipment from Schenectady to New York; a different way for the boat trip from New York to Bordeaux; and a third way for the rail trip from Bordeaux to the Tuileries. If they had been shipped by boat, in the same package that they left Schenectady, the cubical content and hence the shipping charge would easily have been trebled.

The loading of the car is not only studied but it must be made permanent. The creeping of the load on a car must be prevented.



Boxing for Export Shipment of a Marine Generating Set. Note how wire netting is attached for preventing mice entering through the breathing holes

The bumping and rolling of a railroad train has been found to loosen the struts and braces unless the work is well done, and occasions have been known where the trains have been wrecked, bridges damaged, and tunnels jammed with a tangle of machinery, locomotives, and freight because a packer did not know his business.

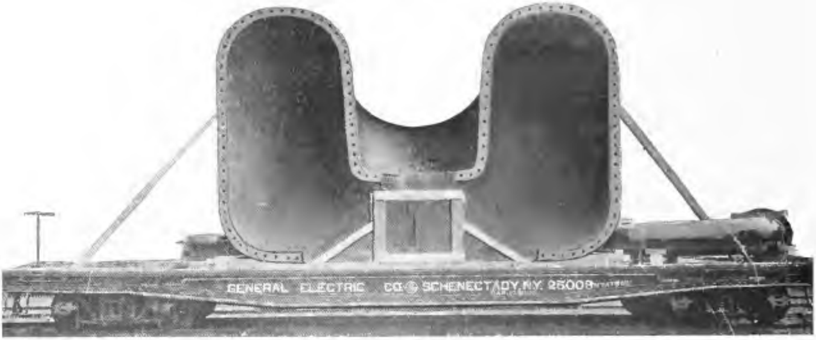
One of the means of preventing shifting of the load on a railroad car is to load the car uniformly, not only longitudinally but laterally. The struts and braces are placed with great skill so as to prevent a concentration of the load at the end, the center, or on either side of the car.

Experience has shown, particularly in export shipment, that cautions reading RIGHT SIDE UP, HANDLE WITH CARE, FRAGILE, and even GLASS are not respected. Efforts to keep machinery in an upright position throughout an entire voyage are shown in the photographs. Large black arrows are painted on all four sides of the box with the word TOP placed permanently near the head of the arrow as well as the French word HAUT, and the Spanish word ARRIBA. But if you were a Hindu unloading an elephant it is quite doubtful if you would exert yourself to let this package down gently, right side up on the barren wastes of India, or during a tropical storm in South America or China.

Baffling the Weather Man

Expert packers have no difficulty in protecting machinery from rain and snow, wind and heat, or from the mist on the sea. This is as easy as for an ordinary citizen to wear a mackintosh or carry an umbrella. But the real deep study has been to overcome the accumulation of moisture on the machinery due to humidity, especially the humidity of foreign countries.

Various experiments were tried to overcome this trouble. Special kinds of cloth and special coatings of tar were used, and in some cases an entire metal box of zinc or lead was constructed and apparently hermetically sealed up. But these all failed of their purpose. In one instance a motor was totally enclosed in a zinc tank and soldered tight. Two years later it was opened and there were three quarts of water in the bottom of the tank. Apparently, due to jarring and vibration, some little crack or pinhole had opened up and the box had begun to "breathe." The dampness would condense against the cold machinery, and then in the daytime when the temperature



Upper Half of Exhaust Covering of the Detroit 45,000-kv a. Steam Turbine. Note bracing for steadying and distributing the load

rose the box would breathe out dry air. Thus with the rising and the setting of the sun moisture was carried into the box, which was thought to be hemetically sealed.

The shipping men were baffled—they gave up the problem as hopeless. Someone thought of consulting Dr. Steinmetz, the chief consulting engineer of the General Electric Company. And here is shown the advantage of a complete organization where the experts in different lines can exchange information for the benefit of the several departments.

Dr. Steinmetz advised that the boxes be made open instead of closed, and that breathing holes be provided to keep the temperature inside the box practically the same as the temperature outside the box. The Shipping Department conducted many experiments and eventually a method was developed which solved the problem. The

The rain and snow is excluded by tar-coated building paper strengthened by mosquito netting. This light filmy mosquito netting is quite useful in adding strength to the tar paper and serves the purpose admirably.

The Fight Against Rust

For packages that go to foreign countries an additional covering of what is known as carriage cloth is used underneath the covering of tar paper. This carriage cloth is wrapped around the machinery itself, and is held tight by strings and ropes so that no matter what position the machinery may be in it is well protected.

For many years the shipments of American machinery were damaged by rust, although they were perfectly protected from rain and storm. This rust evidently was produced by the moisture in the air, i.e., the humidity.

great generator for the London Underground Railroad were delivered free of rust, but it was found that the mice on shipboard had taken advantage of the breathing holes in the boxes, and had eaten off the insulation from some of the copper wire. So from that time on a wire screen or netting was tacked on the inside of each hole.

The breathing holes are not made too close to the top, bottom, or sides, for fear water might wash into them. To provide against the possibilities of these boxes being laid over on one side, thus bringing the holes on the top, a funnel-shaped shield is tacked on the inside of the box around the hole, and this shield or funnel traps the water and diverts it down the side of the box, away from the machinery.

Shipping experts in Schenectady who have had unequaled opportunity to study these questions say that shipments of General Electric apparatus which may now be lying at the port of Vladivostock in Russia are as free from rust and other damage due to the elements as though they had been standing in the shops of the General Electric Company.

The method just described is for large pieces of apparatus. For the smaller delicate apparatus, such an instruments, which are liable to damage from moisture in very minute quantities, a pitch-covered canvas is used inside the box, and not a complaint has been received from any quarter of the world in the three years that this method has been in use. This is applicable especially for boxes which are small enough to be handled by one man. This pitch-covered canvas is more effective than any metal casing because of its clinging qualities, and the fact that if subjected to pressure or distorted it is not in any way weakened; for the more it is compressed the tighter the wrapping becomes —exactly opposite to the case of a metal box.

Panama Locomotives Shipped Complete

From the customer's standpoint it is ideal to receive the completely constructed machine. For instance, the Panama locomotives were built at the factory, shipped on the decks of the vessels, and when lifted onto the pier at Panama they were run off by their own power.

The ideals towards which the packing experts strive, in the order of their importance, are as follows:

1. Get the shipment to the customer without breakage.
2. Get the shipment to the customer without [illegible] [illegible]
3. Deliver [illegible] ideal [illegible]
4. Deliver it [illegible]
5. With [illegible] portance [illegible]

Finishing Touches Between Armature and Skids to Prevent Rust

So important is the work that a shipping committee has been appointed to standardize this portion of the General Electric Company's work at all of the different factories. The Committee consists of eight men from the various works, and they meet four times a year or oftener to discuss problems and settle matters of detail and policy. This committee thus acts as a clearing house of shipping information and experience.

Each type of apparatus has assigned to it a definite box, of definite size and material, put together in a certain way, wrapped, tagged, etc., according to definite specifications, written down and even illustrated.

There are 750 kinds of boxes represented, and directions covering many different methods of loading flat cars, in which are specified the braces, struts, skids, etc., which should be used. All these add not only to the safety but to the speed of shipment.

Government Recognition

The United States Government recognizes the value of expert shippers and has created a Committee on packing, boxing, and crating, as it is now shipping untold millions of tons to all parts of the world.

This Committee consists of Mr. D. L. Quinn of the Forest Products Laboratory at the University of Wisconsin, Mr. P. C. Morganweck of the International Harvester Company at Chicago, and Mr. M. C. FitzGerald of the General Electric Company at Schenectady. The Committee has prepared standard specifications for packing different types of supplies, apparatus, etc., and personally instructs those officers who have charge of this work at Washington and at the various points of embarkation.

Many officers have visited Schenectady in order to receive instructions in the standardized method of packing and shipping. It is gratifying to hear that Major General George W. Goethals requires that these specifications be followed to the letter in the actual work of shipping goods abroad.

As an example of the benefit of the recommendations of this Committee, we will cite one instance in particular—a shipment of 10,000,000 cases for France. The Committee was asked to give its recommendations on the boxing of each of these 10,000,000 cases. Although the proposed cases had been whittled down as far as the manufacturer thought it could be done with safety, the Committee developed a new method which cheapened the manufacturing cost of each box 25 cents and also reduced its cubic displacement one half cubic foot. This saved $2,500,000 in the cost of the boxes; but this is not the whole story. The 5,000,000 cubic feet of shipping space which was saved is worth from two to five dollars per cubic foot at standard freight rates, or a further saving of approximately $20,000,000. And again, from the standpoint of conserving ship space, 5,000,000 cubic feet displacement is equivalent to 125,000 tons, as 40 cu. ft. of this character is rated as one ton in marine estimates. Thus this one recommendation of the boxing and crating experts conserved shipping equivalent to the combined cargo space of 31 4000-ton ships.

Salvaging Industrial Wastes

By W. Rockwood Conover

Economist, General Electric Company

A beneficial result of the war, and one which we hope will be lasting, was the great effort on the part of industry to eliminate waste. The government campaign for conservation of materials showed the manufacturers what could be accomplished, and they were enthusiastic to put these economies in force. The salvaging of industrial wastes is a big factor in the economy of materials, and in this article Mr. Conover briefly outlines what saving can be accomplished by reclaiming scrap materials.—Editor.

A new interest has been awakened in the subject of salvaging wastes which is obviously the direct result of the world war. Conservation has within the brief space of less than two years become a world-wide slogan. The world is fast becoming aroused to the fact that saving is now one of the chief, vital principles of existence; that the extravagant, wasteful practices of the past mean ruin to the nation continuing them. The winning of the great conflict depended not so much upon guns and men, not so much upon equipment in the field, as upon the careful saving and judicious use of every fabric and fiber, of every piece of metal, and of every element of human and mechanical energy.

In industry these words have assumed a new and more vital significance for us since America's entrance into the world struggle. Saving and utilizing the by-products of production have gained a new and sudden prominence among other established practices of recognized value in engineering and manufacturing. The Government demanded to know what we were doing with the materials entrusted to our care. It mattered not whether we manufactured specifically for the military needs of the nation, or for private commercial ends—the question remained the same: What were we doing to conserve? It is plainly the duty of industrial managers everywhere, of the leaders of big business of every kind, and of the citizen in every calling in life, to study the conservation of waste and the salvaging of the by-products of production and every-day living. Not a pound of metal or fabric; not an ounce of essential oils or chemicals; not a piece of leather, rubber, or wood; not even a scrap of paper should be allowed to go to waste or escape the process of reclamation.

Salvaging industrial wastes has a more far-reaching significance than most people realize. It is obvious that unnecessary consumption of finished fabrics or failure to reclaim by-products necessitates increased production of raw materials. Increased production of whatever nature means additional labor, additional transportation facilities, the tying up of railway equipment and congestion of traffic, and an increased cost of living.

It is manifestly of great importance, if we are to secure a practical working basis of economic manufacturing, to establish systems of control in every factory in the land. Systems must be set up which will not only insure the economic consumption of all materials employed in production, but which will also prevent every form of unnecessary industrial waste and accomplish the complete reclamation of all classes of by-products. Regular stock department reports are most essential for the purpose of showing the amount of various classes of material delivered to the manufacturing floors; but the establishment of systems of prevention and control, which preclude the possibility of waste, is of far more importance and of far greater effectiveness in securing the results we are seeking to obtain.

With the exigencies of the war, most difficult employment problems arose, of a character which the manufacturer had never before faced. Much of the new help which he employed had to be taught the simplest rudiments of shop practice. This condition materially affects precision in productive processes and is a fertile source of increase in industrial wastes. How to meet this condition is one of the serious problems of the day and one in vital need of being solved.

In the larger industries engaged in the manufacture of a diversified mechanical and electrical product, and in all industries the products of which are composed chiefly of metal parts, such as machinery for mills and factories, agricultural and traction machinery, automobile products, etc., metal scrap, such as steel, iron, copper, brass, and various alloys, constitutes the greater portion of the valuable by-products. The aggregate of by-products reclaimed annually in some of our chief industries amounts to many thousand tons. In one of the largest electrical industries, the General Electric Company's plant at Schenectady, it has amounted in the past two years to more than 40,000 tons per year.

In the bigger mechanical industries, like the Schenectady plant, it is essential to provide a buildin[illegible] exclusively to reclaim[illegible] building should be equipp[illegible] and broad gauge track at[illegible] ing cranes for the rece[illegible] material and also for loadi[illegible] There should also be an equipm[illegible] separators, metal shears, pre[illegible] and bundling machines, reduc[illegible] melting pots, and necessary [illegible] saws, or other tools required in tak[illegible] and preparing material for shipment to [illegible] founders and dealers. The contiguous outside area should be provided with ample trackage, loading platforms, storage sheds, and with gantry crane service for the handling of heavy materials and castings which must be stored while awaiting disposition. In small plants a section of one of the shops or storehouses can usually be assigned to by-products. In these smaller factories the facilities and equipment required for reclaiming and handling scrap will necessarily depend upon the character or class of product manufactured, and may be limited to comparatively few machines or tools.

Metal By-products

For purposes of accounting it is always desirable to establish a system whereby the individual shop departments will receive credit for all scrap produced.

In the large boring mill and machine departments, steel boxes of approximately two tons capacity are placed in convenient localities near the machine tools, into which the chips and turnings can be shoveled with facility by the machine helpers or floor sweepers. These boxes are provided with hinged ends to facilitate discharging, and with handles for lifting with the shop cranes and conveying to the cars. This obviates the operation of wheeling out of chips to the sidings in barrows by the floor labor gangs, thereby effecting a good economy in cost of handling. This class of scrap is usually shipped in car lots in its original form, and weights are tallied on the railroad scales at the scale house.

The process of briquetting steel and iron borings and turnings, which has been established in several of the larger manufacturing centers of Europe, in the cities of Berlin, Vienna, Buda Pesth, Stolberg, Chemnitz, Cassel, Milan, and in Switzerland at Winterthuer, has in recent years come into use to a limited extent to this country. It is one of the new developments for which, in connection with certain prospective metallurgical reactions, there appears a somewhat attractive field about to be opened up, and one in which the big industries of the country will more generally take interest in the future. In giving consideration, however, to the increased market value of steel and iron borings and turnings which have been briquetted, the cost of the installation and operation must not be lost sight of, which may and does have a very material bearing on the net gain to be credited to the operation. This is especially true where liberal market figures are already being obtained for these by-products shipped in their original form. The cost of installation in a number of cases must include the erection of new buildings for the purpose, which will involve an important item of investment to be charged against the receipts. In general, the larger industries throughout the country are still adhering to the practice of shipping their borings and turnings unbriquetted in car lots.

In the manufacturing departments having machine tool sections devoted to the machining of small parts, and in the automatic machine departments, the chips and turnings consisting of steel, iron, copper, brass, composition, babbitt, etc., are collected in steel barrows and containers, weighed, tagged, and sent to the general scrap building. The tag attached to the container designates the department from which the chips come, class of material, and weight. As far as practicable the scrap from these departments is kept separate in the processes of machining, the chips from one kind of metal being removed from the tool pans as soon as the job is finished and before another metal is started cutting. Chips removed from machines operating with cutting oils are run through oil separators before delivery to the scrap building. This process is a most essential one, the oil reclaimed amounting in some cases to a barrel, and in others to more than a barrel per ton of chips, according to operating conditions. This oil should be mixed with a proper proportion of new oil to bring its cutting value up to standard requirements.

Mixed chips and turnings from machines operated on short jobs, involving frequent changes of metal, and from those operated on parts assembled from two or more metals or materials, are collected by the floor sweepers, and forwarded in barrels to the scrap building for sorting and loading.

Apparatus and materials designated by the mechanical inspection force of the shops to be scrapped have a blue tag attached at the time of inspection, and are sent to the by-products building where they are taken apart and all materials of value saved. Benches are provided for the men who do the work of disassembling, and the various metals and materials are sorted into barrels, boxes, or bins in preparation for shipment or consumption in the home foundries.

Babbitt scrap is usually an important item in most mechanical industries. Frequently it is mixed with iron, brass, or composition, as is the case where it comes from machines employed on the process of turning and boring bearings, etc. When mixed with iron it is put through the magnetic metal separators and is then ready for reduction in the babbitt furnaces with the clean babbitt chips collected from the shops. The furnaces are located in an addition adjoining the main scrap building which is devoted exclusively to smelting and casting pigs. The capacity of the furnaces is 3000 lbs. per run, or approximately 12,000 lbs. production per day. The pigs cast from these chips are worth the price of new babbitt metal in the open market. Babbitt dross contains a high percentage of pure metal when reclaimed, and is worth approximately 85 per cent of market pigs. Lead dross yields about the same relative value in reclamation. During the year 1917 nearly 400,000 lbs. of babbitt pigs were cast from scrap and used for home consumption, and more than 300,000 lbs. of mixed babbitt and babbitt dross were saved and sold to the outside market. All lead dross is also carefully saved and disposed of in the same manner.

The shop foremen should give special attention to saving all copper, brass, nickel silver, nickel, aluminum, or other grades of metal in whatever form. This would include wire scrap, clippings, stampings, and cuttings from both metal sheets and solid stock left over from productive processes. Care should be exercised to prevent workmen from throwing small pieces of scrap metal into the shop waste cans, and the refuse from these cans should always be sorted, and all metals picked out before sending the waste material to the factory dump or destructor plant.

Foundry slags and wastes from smelting furnaces in mills and reduction plants pay good returns on the labor expended in the process of reclaiming. The slag from the cupolas and furnaces should be carefully sorted and screened, in which case there will be little material of value left. The percentage remaining will not usually be sufficient to require the operation of a cinder mill. In the brass foundry there is always an accumulation of metal waste which yields a good return. This residue requires more care and equipment in the process of reclaiming. In general the coarser portion is put through a crusher to render it in shape for screening or separating by electro-magnetic process. With suitable jigs, screens, tables, and magnetic separators, all of the finer particles of metal can be saved and that portion known to the trade as brass dross can also be fully reclaimed. It is good practice to gather all the refuse from the foundry floor which may contain particles of metal, and by means of one or more of the several reclaiming processes, reduce the metallic portion to a condition and shape suitable for use in charging.

The by-products from reduction and smelting processes in laboratory furnaces and retorts, and by-products from laboratory production in general offer a wide field for valuable conservation work. Many valuable metallic elements in the form of wastes and residues, such as aluminum, molybdenum, tungsten, barium, etc., can be reclaimed and used again in production with a comparatively greater profit than in many other classes of manufacture because of the initial cost of these materials.

Building Construction—Improvement and General Repairs

Waste materials left over from building construction and repair work comprise a large list. Alterations and repairs to buildings often involve the removal of steel angles and beams, sheet metal, piping and wiring, cables, etc. All of this product of factory additions and alterations is of the highest value. Much of it can be saved and applied on other jobs. The same is true of materials used on extensions and repairs to plant trackage and on repairs to machinery and shop tools, and improvements and repairs in general. It is good practice to establish a system of clearing up left-over materials immediately on completion of work, and making disposition either by returning to stock or sending to scrap. Regular inspections of manufacturing departments and of contiguous areas between shops and buildings, as well as storage sheds and platforms, should be made with a view of collecting and disposing of metals and fabrics left over from production [illegible] and waste product [illegible] on [illegible] and repairs [illegible] equipment special attention [illegible] to keeping the tool [illegible] condition with a reasonable [illegible] labor and material for repairs [illegible] shops there is a tendency to discard [illegible] tool and purchase new equipment [illegible] large additional cost, rather than make necessary repair. It is also [illegible] establish a system of collection of lathe and planer tools which will insure that they are gathered regularly from the machine floors as they become worn, and sent to the forge shop for repointing and grinding, after which they may again be given out from the tool stock room to the workmen. It is a common practice in some shops to leave partly used cutting tools lying about machines and cupboards until large accumulations result. Most of these tools can be repointed several times, or reshaped for other processes to good advantage before they are completely used up, and the remnants melted over into new stock. Each tool should receive careful inspection and be put to the fullest service for which it was designed before being replaced by a new tool.

Tool steels in various shapes and sizes are often left lying about the machine sections and tool-making departments without any good reason except lack of attention to system on the part of the supervisor in charge. All these remnants and left-over pieces are of the utmost value either in new tool production and repairs, or for melting and converting into stock sizes.

Bolts, nuts, washers, pins, etc., left over from productive jobs should be returned promptly to stock by the workman. Unless this practice is followed, these articles are apt to lie around the benches and floors indefinitely and finally reach the scrap department with other materials as waste products. It is the practice of the supervisor in charge of the main by-products building and of the collection and disposal of scrap in the Schenectady plant to systematically save all materials which may be of further use in the manufacturing departments or in the work of maintenance and repairs. Particular attention is paid to the sorting and preparation of all the various classes of metals in order to meet the market rulings as to condition, size, and form in which the different grades must be shipped, and also to obtain the highest quotations which the market affords.

Experiences with an Electric Power Plant Eleven Degrees from the North Pole

By Jerome Lee Allen

Member of the Crocker Land Expedition

The discovery of the North Pole is no longer news but probably it is news to learn that a complete electric generating plant has been installed and operated within a few hundred miles of that apex of the earth which man, after years and numberless failures, attained by traveling with only the barest necessities which would support life during that flying visit. The following narration of experiences in connection with this arctic electric plant is of particular interest on account of the geographical location of the plant and of the prevailing severe climatic conditions.—Editor.

The Crocker Land Expedition sailed from New York, July 2, 1913, on the Newfoundland sealing ship *Diana* and included in its outfit an electrical equipment unusually complete for an Arctic destination. In addition to a 3-kilowatt, gasolene-electric generating set loaned to the expedition by the General Electric Co., an 80-ampere-hour 125-volt storage battery loaned by the Electric Storage Battery Co., and a radio set with two 500-cycle transformers loaned by the Atlantic Communication Co., there were included an electric oven, half a dozen disk stoves, lamps, wiring fixtures, and a complete control board for the generator, radio dynamotor, radio transmitter, and storage battery.

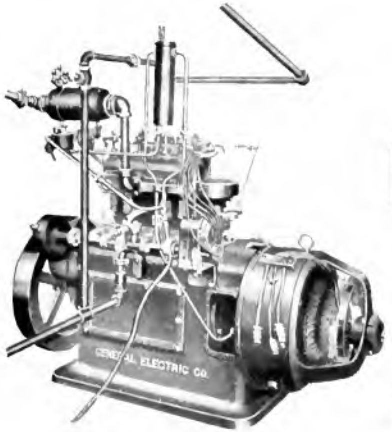
The extreme cold of the northern latitudes, and the necessity to transport with the expedition all the engine fuel to be used during the sojourn, made it seem desirable to utilize every possible calorie of the fuel in some way. Accordingly, it was planned to heat the camp with the heat not converted into mechanical energy by the engine. For the purpose, two gasolene-electric railway type radiators were employed in connection with a 300-gallon cooling tank fitted with a special piping arrangement for abstracting the heat from the exhaust.

Since it was considered likely that the apparatus when landed in the Far North would have to be transported over difficult places, possibly over glaciers and sea ice, everything was shipped completely knocked down. To be certain of being able to assemble the many pieces properly after arriving at the destination, where one couldn't well write to the factory for instructions, the author spent several months in the Testing Departments of the Schenectady and Erie Works of the General Electric Company.

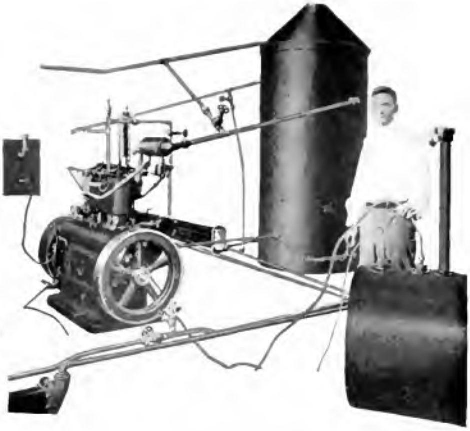
After an adventurous trip via Labrador, where the ship tried to go by a short cut overland, and after loading and unloading the cargo four times en route, the expedition reached Etah, North Greenland.

Etah is not a port. It is not much of anything except a rather prominent glacial drift formation back in a fjord which forms a relatively good harbor. Four or five Eskimo igloos serve to shelter natives who might choose this spot for their winter home. The members of the expedition selected a site for their house at the foot of the glacial drift, and began work on the foundation immediately after completing the final unloading of the ship, which had to be done on the rocks at a point about half a mile from the camp site. As it was necessary to set up the big tank and a few other large parts of the plant before the walls were built, we took time off from carpenter work on the house to ferry over the parts. Here we began to appreciate the great strength of the husky little brown men. These Eskimos took a piece of sealskin line and made a carrying sling, "tump-line," and walked off with a load on their backs that would have made our best men grunt. E-took-a-shoo, one of the men who accompanied Dr. Cook on his trip, solved the problem of transporting the two 500-cycle radio transformers, the heaviest pieces of which weighed about 350 pounds, by "tumping" them up the beach from the boat to the house.

The house was built thirty-four feet square, with a big living room in the center and bedrooms, photographic room, electrical room, and workshop around it. The walls of the electrical room were built after the 300-gallon tank had been set in place. As it was not feasible to construct a cement foundation for the generating set, it was set up in the electrical room with the bed-plate bolted to two-by-fours laid crosswise on the flooring. Due to differences in natural periods there was no more trouble experienced from vibration than there would have been from a sewing machine. The complete plant having been installed with radiators in the rooms, the batteries were set up temporarily in the workshop for a waking up charge. No difficulty whatsoever was experienced in setting up the plant; probably few have ever been set up more quickly and easily. It was, therefore, with exultation at our success that one of our thousand cases of fuel was broken open and the tanks filled. Gingerly the engine was cranked and the kick-off listened for, but it did not occur. It was cranked again and again and again, yet it would not start although the timing of the ignition and valves were correct, the compression good, and the cylinders receiving



3-kw. Gasolene Electric Set with Kerosene Gas Producer, Exhaust Side. Crocker Land Expedition



3-kw. Gasolene Electric Set and Accessories Crocker Land Expedition

the charge from the carburetor. Mentally and physically exhausted by cranking, the author was relieved in turn by the geologist, the zoologist, the doctor, the cook, and finally by the Eskimos; but with the same results. Ether from the medical supplies was used to prime the engine which exploded as long as the charge lasted. The carburetor was then filled with ether and the engine ran for a few minutes as though it never intended to stop; but it stopped when the ether was exhausted. Finally the fuel was drained from the tank, another case opened, and the tank refilled. Success crowned these efforts. In the intense haste to get the engine going before the Arctic darkness closed in for six months, no one had noticed that the first can opened was of kerosene [illegible] in a case marked gasolene.

As the house had been completely wired before the engine was started and the lamps were in the sockets, the generating room became a blaze of Mazda brilliance when the main line switch was closed. The old-timed darkness of the six months' winter night was gone from our Arctic headquarters, *eleven degrees from the North Pole*.

The storage cells had been placed in a locker built for them very nearly over the big stove in the living room. Access to them was from the attic above. The locker was provided with a cover; and an adjustable opening from the living room side provided regulation of warm air. It was thus possible to operate the cells at their best temperature without allowing the gases to escape into the living room. Lamps were of course located in all possible places throughout the house; and a big lamp with a bright reflector was kept burning in front of the door, so that Eskimos, traveling from their homes two or three hundred miles to the south, got their first impression of this wonderful white man expedition from their sledges miles before they reached the house. A light in the Weather Bureau instrument shelter, some distance from the house, made the watchman's hourly trip less fraught with the dangers that lurked in the dark outside the house. (These latter were mainly those of stepping on a nest of curled-up puppies or of bumping one's head on the sledge of some newly arrived Eskimo guest who had cached his sledge up on top of the instrument shelter as a means for keeping his hungry dogs from eating the sealskin lashing which held it together.)

The first revelation came when the first charge of the batteries had progressed about three or four hours. The 300-gallon tank of water began to get so hot that the radiators, duly radiating the heat, made the house so hot that every door and window not nailed shut had to be opened. The house had been built well; it had not been intended that any heat should escape, and very little did. Soon it became necessary to draw off some of the hot water and add chunks of ice from the sea. This first charge lasted for two or three days, and during this time it was realized that there was more heat generated than was desirable.

The Eskimos naturally enjoyed the wonders of electricity but they are prone to be stoic when it comes to expressing surprise. They can very satisfactorily explain anything by their word "ig-mi-ny" which means "it comes of itself." The ignition system seemed to puzzle them the most, and probably every Eskimo of that tribe, the northern-most people of the world, had a shock from the magneto.

The attempt at radio communication was disappointing. Nothing could be done without a suitable antenna, and it was impossible to get the ship over to Flagler Fjord, on the Ellesmere Land side, where there is a suitable cliff for supporting the antenna. Wires were, however, put up on the hills around the house, and led from a cliff to a 40-foot mast at the house. About the most interesting fact learned was that there is no static whatever and no noticeable effect from the aurora up there.

Since it seemed likely that messages would be sent broadcast to the expedition, in the hope of our picking them up, attempts were made to fly kites to support the antenna. The kites were of the 8-foot type used by the Weather Bureau. It was soon learned that the winds at the camp were too gusty for kite flying. The house was so situated that sometimes the wind would blow straight down upon it from the hills and valley above. In a last endeavor, the plant was dismantled and moved in our whale boat to a small island about three miles from shore. It was hoped that out there we should have more favorable winds and be able to keep up a kite long enough to establish communication.

The 300-gallon cooling tank had to be cut in half with a chisel to get it out of the house. Only the lower half was transported; the next summer the upper half was used for an outdoor bath tub. Enough pieces of boxes, left-over boards, and empty tins were picked up to build a house on the island, about eight by twelve feet with a slanting roof five by seven and one-half feet. This was walled in with boxes of provisions, rocks and snow, and in this little place was installed the generating plant, the radio transmitter, the storage battery, the electric oven, the switchboard, a heating stove, two bunks, and a table. Profiting by the experience in overheating the main house, the entire cooling tank was placed outside this time and the piping arranged so that the cooling water intake pipe came up through the bottom of the tank to within an inch of the top. The preliminary of starting was to fill the tank with water which, of course, in a few minutes became solid ice. Under the ice pressure the tank would warp and twist, but since it was open at the top there was not enough pressure to burst it. A plug screwed into the top of the intake pipe prevented water from getting inside it. The ice bulged up and rose to the level of, or possibly higher than, the top of the protected intake pipe. When it came time to start up, the cap on top of the intake pipe was unscrewed. A gallon of hot water from the stove, poured in on top of the ice after the engine was started filled the pipe and started the program. The outlet warm water coming out on top of the ice began to melt the whole mass and a steady temperature was maintained. At the end of the run, the water was drained at the lowest point in the intake pipe. This took all the water out of the piping, but only about a gallon out of the tank. The cap was then screwed on the top of the intake pipe and the tank was left to freeze again. This cooling system was a real success.

However, the purpose for which the power plant had been laboriously moved and a second time set up proved to be of no avail, for the kites used to support the antenna were smashed one after another. The last kite met the very inglorious end of being smashed by two innocent puppies which wandered out to the island and made a bed of it.

The house on the island was lighted, inside and outside, by 60-watt Mazda lamps. A string of six lamps across the kite-flying stand lighted up the whole end of the island. This blaze of light must have looked very strange and wonderful to the traveling Eskimo to whom years of traveling in the dark winter nights, up there where Cassiopea and the Big Dipper circle around directly overhead, with the North Star as a center, and never set, have given a sort of extra sense of nocturnal navigation.

Having only a heater stove at the island, the electric oven was used for baking. Saturday was charging and baking day.

The generating [illegible] whole two years' charging [illegible] at fifteen per cent [illegible] renewal necessary was [illegible] bearing.

In the spring of 1915, the [illegible] given a decommissioning charge [illegible] lyte taken out, and packed for [illegible] home. The plant was dismantled and [illegible] the tank given to an Eskimo to [illegible] seals in, and then followed the wait [illegible] for the ship to return.

The Cam-operated Railway Controller

By R. S. Beers

Railway Equipment Engineering Department, General Electric Company

An early description of the cam operated or PC railway controller appeared in the October, 1915, General Electric Review. That was about the time the actual development work had been completed. Since then this type of controller has been put in service under all the various conditions of electric car operation. This article presents the confirming evidence that the cam-operated controller has fulfilled in a most pleasing and satisfactory manner the expectations of the engineers responsible for its design, and describes the salient features of its operation.—Editor.

Following the development of the cam-operated controller several years ago and after the first sample controllers had been given all the tests feasible under factory conditions, several equipments were installed for service trial on cars of the New York subway. While in operation under the most severe and exacting railway service in the United States, they were intelligently criticised by a very capable corps of operating men. As is to be expected with any entirely new development, minor modifications were necessary. These consisted chiefly in rearranging parts of the controller to secure greater accessibility. At the same time, positive proof was obtained that the fundamental principle of operation was entirely satisfactory.

The controllers were so successful that the number was soon increased to 124, and subsequently the number has been further increased, until now the Interurban Rapid Transit Company has 490 in operation.

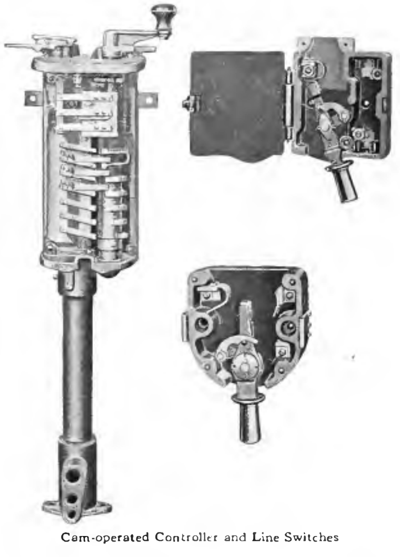
In Boston, 40 of these equipments are operating in the same trains with type "M" control on the elevated, while on the city streets there are some 100 equipments at present and it is expected that there will be as many more in a short time. Philadelphia is using 100 of these controllers on the cars carrying workmen to and from the Hog Island Shipyard. This number will soon be increased to 130. For strictly interurban work cam controllers are now operating cars in the states of Maine, Massachusetts, New York, Pennsylvania, Maryland, Ohio, Michigan, and Oklahoma, while completed controllers for England, Cuba, Spain, Mexico, Australia, and Japan insure that this type of control will soon be operating in these countries.

Car equipments may be roughly divided into two classes, one for city and light interurban service and the other for elevated, subway, and heavy interurban work. To meet these requirements of service in the best manner, the cam type of control has been designed in two general sizes. The small size for city and light interurdan service is small enough to install on the modern city car with low steps and 24-in. wheels. The large size controller is for elevated, subway, or heavy interurban service. These two sizes are necessary owing to the difference in current capacities required. Each size possesses the same features of sturdiness, accessibility, and safety.

Various forms of each size of controller cover the car equipment field, which includes cars with two full-field motors, cars with two tap-field motors, and the same combinations using four motors. These various forms differ only in the reversers, motor cutouts, and wiring. In fact, the four-motor full-field controller is used with four tap-field motors by adding a separate switch for tapping the fields.

The cam controller is more analagous to the simple drum controller than any previous multiple unit control, as the cams absolutely insure a definite sequence and fixed relationship of closing and opening the contactors, which is unobtainable with individually operated contactors. At the same time, the combining of all the motor circuit control elements, such as the line breaker, overload relay, accelerating relay, contactors, reverser, and motor cutouts in a single box reduces the materials required and time of installing. In addition to this feature there is a decrease in weight of the controller itself as well as the elimination of a number of iron hangers which are needed when suspending an equipment consisting of several separate pieces of apparatus.

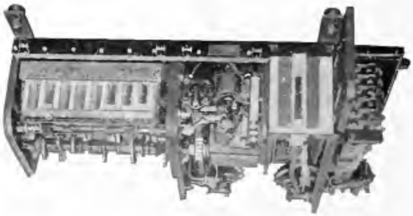
While the use of cams for closing the contactors was comparatively new, it had



Cam-operated Controller and Line Switches

proven so successful on the series-parallel switches of the Butte, Anaconda and Pacific 2400-volt electric locomotives that no doubt was felt for its successful operation on the cam controller. This has now been proved by actual operation, as controller cams that have been in service for three years show hardly a sign of wear.

The use of cams and cam shaft, giving a definite sequence of closing and opening the contactors, is of particular advantage in that it substitutes mechanical interlocking



Small 600-volt Cam-operated Controller

for the electrical interlocking required with individually operated contactors of previous control systems. This feature makes a very strong appeal to the operating man who has experienced trouble in the past with the small contacts of electric interlock switches.

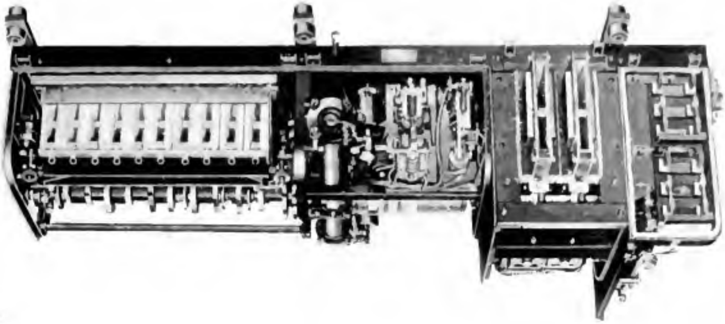
This substitution of mechanical for electrical interlocking has made feasible a control system for automatic current-limit acceleration that is less complicated than previous automatic controls of either magnetically or pneumatically operated contactors.

Automatic acceleration has been desired in the past but the additional complication, necessary with individually operated contactors, has more than offset the advantages for all but a few classes of service. The simple arrangement of control circuits with the cam-type control has made it possible to use automatic control for all classes of car equipment. This has proved of advantage in saving power and reducing shocks to the equipment, and, as a smooth acceleraion is obtained without any attention from the motorman, greater comfort results for the passengers. At the same time the motorman can give his undivided attention to signals or to traffic in front of the car. This is of great importance today with the congested condition of traffic in city streets.

While an acceleration depending upon a fixed current value is suitable for all normal conditions of electric car operation, emergencies arise, such as starting a car on a steep grade or on a curve, where some means of increasing the torque on the motors is essential. Provision is made in the cam system control for such emergencies by including on the master controller a separate handle, called an advance lever. The control is so arranged that pushing this lever forward advances the motor controller one step, independently of the current flowing through the accelerating relay. By releasing the advance lever and again pushing it forward, the motor controller will advance another step. If desired the motor controller may be advanced through its entire progression in this manner, independently of the current in the accelerating relay.

factory operation of the [illegible] cases where some other feature [illegible] ment has determined the [illegible] automatic electric [illegible] battery potential have [illegible]

The ability to operate the [illegible] very little electric energy and from [illegible] voltage is particularly fortunate [illegible] volt equipments, where some [illegible] source of power is essential for the auxiliary circuits. As the control does not determine the voltage, a value can be selected for these auxiliary circuits that will allow the car lights to be connected in parallel instead of the usual practice of several circuits, each

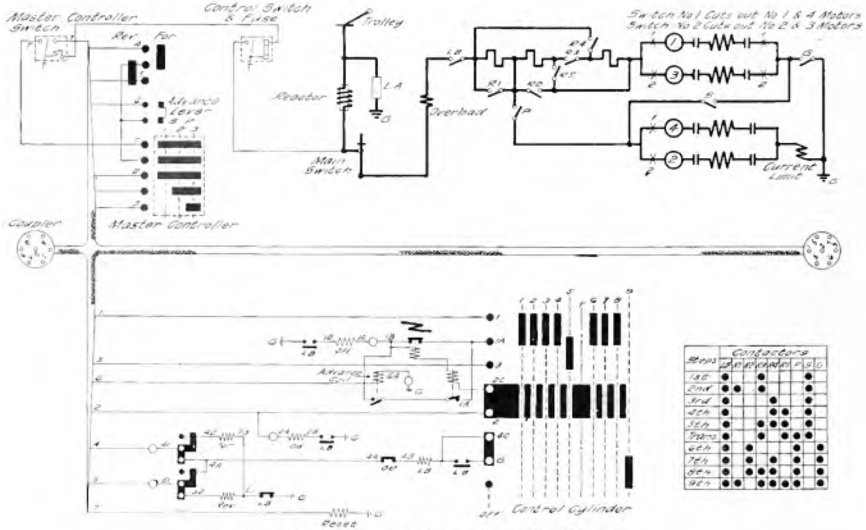

1500-volt Controller


Small Contactor


Large Contactor

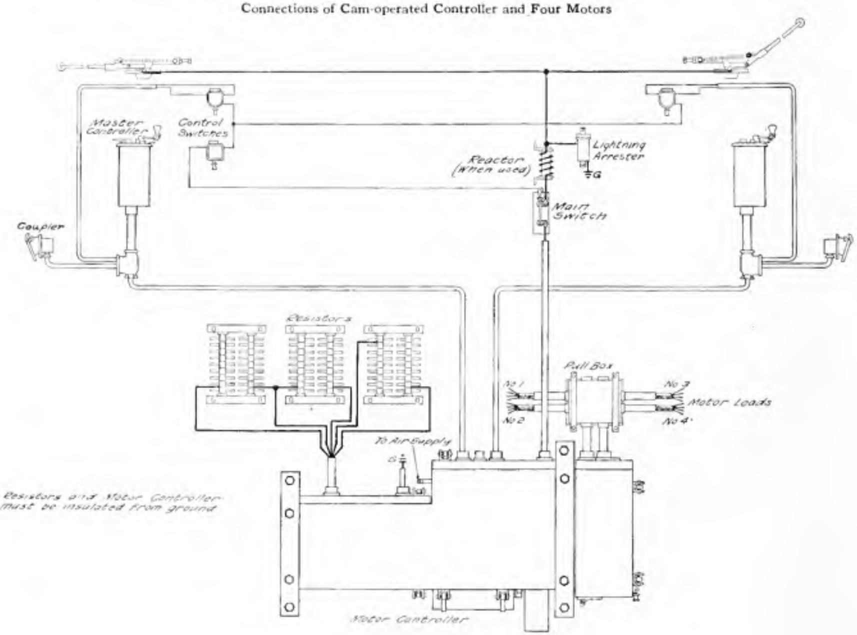
As the cam controller requires only a very small amount of electric energy for operating its magnet valves, either battery or trolley current may be used as a source of supply. On 600-volt equipments, trolley potential is used with resistor tubes connected in series with the operating coils to reduce the current to a value low enough for the satis-

circuit having five lamps connected in series, and will also permit of the use of a headlight without an external resistance. Thirty-two volts meets these requirements admirably as this is a standard voltage for train lighting lamps and as it also allows the filament of a headlight lamp to be concentrated near the focal point of the reflector. A headlight



Steps	Contactors LB	R1	R2	R3	R4	R5	P	S	G
1st	●			●				●	
2nd	●	●		●				●	
3rd	●				●			●	
4th	●				●	●		●	
5th	●			●	●	●		●	
Trans	●			●		●	●	●	
6th	●		●				●		●
7th	●		●		●		●		●
8th	●		●	●	●		●		●
9th	●	●		●	●	●	●		●

Connections of Cam-operated Controller and Four Motors



Arrangement of Car Equipment with Cam-operated Controller with one of these lamps gives a powerful beam on the tracks with sufficient side diffusion to show up objects readily along the sides of the railroad.

The current for these auxiliary circuits is supplied from the trolley through a unique type of motor-generator.* This furnishes almost constant generator voltage even though the motor voltage may vary through a wide range. The regulation is accomplished without the use of an external regulator. The constant potential insures having a powerful and brilliant headlight and uniform interior lighting of the car, which latter is readily appreciated by all.

* This motor-generator and its principle of operation were described in the GENERAL ELECTRIC REVIEW, February 1918, page 124.

MR. F. N. BOYER RETIRES

With mingled feelings of regret and pleasure the many friends of Mr. F. N. Boyer, Manager of the St. Louis District of the General Electric Company, will learn of his retirement from active business life— regret at their loss of his mature judgment, wise counsel, and the benefit of his broad experience in electrical matters, and pleasure to know that it is now his good fortune, after fifty years of service, to be able to unshoulder the cares and responsibilities of business and enjoy the rest and recreation he so richly deserves.

Frank Norton Boyer was born in Reading, Pa., September 9, 1855. In September, 1868, at the age of thirteen, he left grammar school to become messenger boy for the Philadelphia, Reading and Pottsville Telegraph Co., and in the following year was promoted to telegraph operator. From 1873 to 1884 Mr. Boyer was wire chief of the Philadelphia and Reading Railroad Co., in charge of all telegraph wires. In the latter year he accepted a position as General Manager of the Reading Electric Light and Power Co., in which capacity he remained until June 1891, when he went with the Edison General Electric Co., Chicago, as incandescent lamp specialist. In February, 1892, he was appointed Manager of the Incandescent Lamp Department and the Wire and Cable Department, and a few months later, when the General Electric Company was organized and this position was abolished, he became associated with the Supply Department, serving in various capacities, and in 1895 was promoted to Manager of the Supply Department. Mr. Boyer retained this position until 1908, when he was appointed Assistant Manager of the Chicago District. In 1912 he was appointed Manager of the St. Louis District.

"Pop" Boyer, as he was affectionately called by his friends, endeared himself to both his business associates and competitors by his eager spirit of fairness on all occasions.

His genial manner and sterling business qualities engratiated him with members of all branches of the electrical fraternity; he enjoys a wide acquaintance and has hundreds of friends inside and outside the Company's organization, who wish him many years of ease and happiness.

Where to get G-E Service

This page is prepared for the ready reference of the readers of the G-E Review. To insure correspondence against avoidable delay, all communications should be addressed to the G-E sales office, G-E distributing jobber, or G-E foreign representative nearest the writer.

OFFICES AND DISTRIBUTORS IN THE UNITED STATES

LOCATION	G-E DISTRICT OR SALES OFFICE	G-E DISTRIBUTING JOBBER
Alabama, Birmingham	Brown-Marx Bldg.	Matthews Elec. Supply Co
California, Los Angeles†	724 S. Spring. St.	Pacific States Electric Co.
California, Oakland		Pacific States Electric Co.
California, San Francisco†§	Rialto Building	Pacific States Electric Co.
Colorado, Denver†	First Nat'l Bank Bldg.	The Hendrie & Bolthoff Mfg & Sup. Co.
Connecticut, Hartford	Hartford Nat'l Bank Bldg.	
Connecticut, New Haven	Second Nat'l Bank Bldg.	
Connecticut, Waterbury		New England Eng. Co.
District of Columbia, Washington	Comm'l. Nat'l Bank Bldg.	National Elec'l Supply Co
Florida, Jacksonville	Heard Nat'l Bank Bldg.	Florida Elec. Supply Co.
Georgia, Atlanta†§	Third Nat'l Bank Bldg	Carter Electric Company
Illinois, Chicago†§	Monadnock Building	Central Electric Company Commonwealth-Edison Co.
Indiana, Fort Wayne	Ft. Wayne Elec. Works	
Indiana, Indianapolis	Traction Terminal Bldg.	Indianapolis Elec Sup. Co.
Iowa, Des Moines	Hippee Building	Mid-West Electric Co.
Kentucky, Louisville	Starks Building	Belknap Hardware & Manufacturing Co. Inc.
Louisiana, New Orleans†	Maison Blanche Bldg.	Woodward, Wight & Co. Ltd.
Maryland, Baltimore	Lexington St. Bldg.	Southern Electric Co.
Massachusetts, Boston†	84 State St.	Pettingell-Andrews Co
Massachusetts, Springfield	Mass. Mutual Bldg.	
Massachusetts, Worcester	Room 627, State Mutual Building	
Michigan, Detroit	Dime Savings Bank Bldg.	Frank C. Teal Company
Minnesota, Duluth	Fidelity Building	Northwestern Electric Equipment Company
Minnesota, Minneapolis†	410 Third Ave., No.	Peerless Electrical Co.
Minnesota, St. Paul		Northwestern Elec. Equip. Co.
Missouri, Joplin†	Miners' Bank Bldg.	
Missouri, Kansas City†	Dwight Building	The B-R Electric Co.
Missouri, St. Louis†	Pierce Building	Wesco Supply Company
Montana, Butte†	Electric Building	
Nebraska, Omaha	Electric Building	Mid-West Electric Co.
New Jersey, Newark		Tri-City Electric Co. Inc.
New York, Albany		Havens Electric Co., Inc.
New York, Buffalo	10th Floor, Elec. Bldg.	Robertson-Cataract Elec. Co.
New York, Elmira	Hulett Building	
New York City§†	Equitable Bldg., 120 Broadway	E. B. Latham & Company Royal Eastern Elec'l Sup. Co. Sibley-Pitman Elec. Corp.
New York, Niagara Falls	Gluck Building	
New York, Rochester	Granite Building	Wheeler-Green Elec'l Sup. Co.
New York, Schenectady	G-E Works	
New York, Syracuse	Onondaga County Savings Bank Bldg.	Mohawk Elec'l Sup. Co.
North Carolina, Charlotte	Comm. Nat'l Bank Bldg.	
Ohio, Cincinnati†	Provident Bank Bldg.	The F. D. Lawrence Elec. Co.
Ohio, Cleveland	Illuminating Bldg.	Republic Electric Co.
Ohio, Columbus	The Hartman Bldg.	The Erner & Hopkins Co.
Ohio, Dayton	Schwind Building	The Wm. Hall Electric Co.
Ohio, Toledo	Spitzer Building	W. G. Nagel Electric Co.
Ohio, Youngstown	Stambaugh Bldg.	
Oklahoma, Oklahoma City	*†1 West Grande Ave.	
Oregon, Portland†	Elec. Building	Pacific States Electric Co.
Pennsylvania, Erie	Commerce Bldg.	
Penn. Philadelphia†§	Witherspoon Bldg.	Philadelphia Electric Company Supply Department
Pennsylvania, Pittsburgh†	Oliver Bldg.	Union Electric Company
Rhode Island, Providence	Turks Head Bldg.	
South Carolina, Columbia		Perry-Mann Elec. Co. Inc.
Tennessee, Chattanooga	James Bldg.	James Supply Company
Tennessee, Knoxville	Burwell Building	
Tennessee, Memphis	Randolph Building	Electric Supply Company
Tennessee, Nashville	Stahlman Building	
Texas, Dallas†	*Interurban Building	
Texas, El Paso†	*500 San Francisco St.	
Texas, Houston†	*Third & Wash. Sts.	
Utah, Salt Lake City†	Newhouse Building	Capital Electric Company
Virginia, Richmond	Va. Rwy. & Pr. Bldg.	
Washington, Seattle†	Colman Building	Pacific States Electric Co.
Washington, Spokane	Paulsen Building	Pacific States Electric Co.
West Virginia, Charleston	Charleston National Bank Building	
Wisconsin, Milwaukee	Public Service Bldg.	

*Southwest General Electric Company. †Warehouse. §Service shop.

FOREIGN OFFICES AND REPRESENTATIVES

GENERAL FOREIGN SALES OFFICES—SCHENECTADY, N. Y.—120 BROADWAY, NEW YORK CITY—83 CANNON ST., LONDON, E.C., ENGLAND

LOCATION	G-E FOREIGN OFFICE OR COMPANY	G-E FOREIGN REPRESENTATIVE
Argentina, Buenos Aires	Cia General Electric Sudamericana, Inc.	
Australia, Sydney and Melbourne	Australian Gen. Elec. Co	
Brazil, Rio de Janeiro	Companhia Gen. Electric do Brazil	
Central America, New York, U. S. A.		G. Amsinck & Company
Chile, Santiago, Iquique and Antofagasta		International Machinery Co.
China, Shanghai	American General Electric Edison Corp. of China	Andersen, Meyer & Co. Ltd.
Colombia, S.A., Barranquilla		Wesselhoeft & Wisner
Cuba, Havana		Zaldo & Martinez
Dutch E. Indies, Soerabaya, Java	Gen. Elec. Co. (of N. Y.)	
England, London	Gen. Elec. Co. (of N. Y.)	
India, Calcutta	Gen. Elec. Co. (of N. Y.)	
Japan, Tokio		Mitsui Bussan Kaisha, Ltd.
Japan, Yokohama	General Electric Co.	Bagnall & Hilles
Korea, Seoul		Mitsui Bussan Kaisha, Ltd.
Mexico, Mexico City and Guadalajara	Mexican Gen. Elec. Co.	
New Zealand, Wellington, Christchurch, Dunedin and Auckland		The Nat. Elect'l and Eng. Co.
Peru, Lima		W. R. Grace & Company
Philippine Islands, Manila		Pacific Commercial Company
South Africa, Johannesburg, Capetown and Durban	South African Gen. Elec. Co.	
Venezuela, Caracas		Wesselhoeft & Wisner

For business in Great Britain address British Thomson-Houston Co., Ltd., Rugby, Eng. For Hawaiian business address Catton, Neill & Company, Ltd., Honolulu

For Canadian business address Canadian General Electric Company, Ltd., Toronto, Ont.

95-42

GENERAL ELECTRIC COMPANY

GENERAL OFFICE: SCHENECTADY, N.Y.