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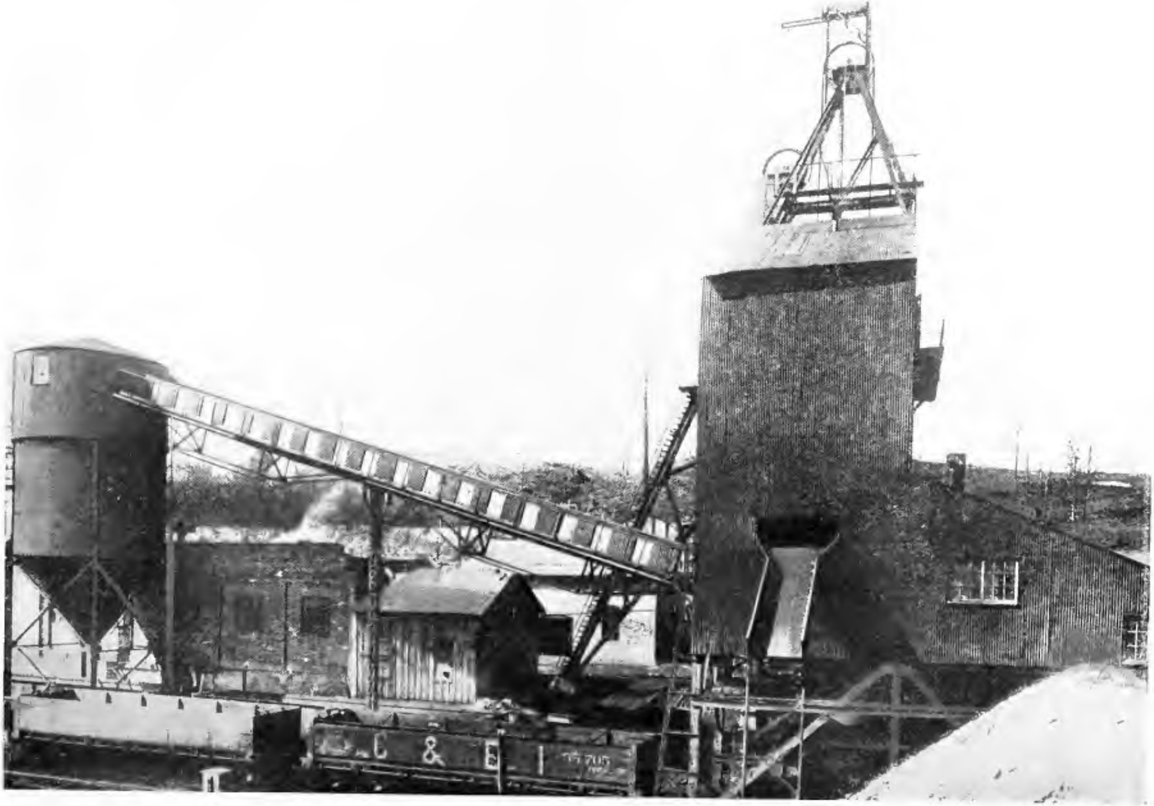

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GENERAL ELECTRIC REVIEW

LIGHTING LEGISLATION

An analysis of the minimum lighting intensities required by the various state artificial lighting codes shows them to be far below the values ordinarily regarded as desirable and even necessary for adequate industrial lighting. Likewise the perusal of the few simple rules comprising the codes proper gives slight impression of the difficulties involved in their formulation and the problems arising from their practical application.

Still the adoption of these lighting codes, brief and reasonable as their provisions undoubtedly are, is of far-reaching importance not only from the standpoints of greater safety and less eyestrain to industrial workers, which is the essential reason for their introduction, but also due to the marked economic benefits they indirectly bring about.

The great advantage of the codes is that the manufacturer must give systematic consideration to the lighting of his factory both under daylight and night conditions. Such attention in the long run, enhanced by the experience and rulings of competent inspectors, should gradually teach an increasing number of employers the marked beneficial effect of providing proper and adequate lighting on the quantity and quality of output, the reduction of accidents, the health and morale of the workers, and the general appearance and up-keep of the plant.

In some cases the state lighting codes are provided with an appendix giving practical information concerning lighting problems, which is an invitation for the industrial manager to seek to lay out his own lighting plans. He would be better advised to put such work in the hands of a competent lighting specialist, as "proper and adequate" lighting involves much more than simply supplying the intensity of light recommended as "good practice." This is particularly true in providing good lighting facilities for endless varieties of industrial operations, some of very different character and requirements often being performed side by side.

The subject of lighting legislation has been diligently studied for many years by the Committee on Lighting Legislation of the Illuminating Engineering Society and the product of this labor has been embodied in a few simple rules termed the "Code of Lighting Factories, Mills, and Other Work Places." These rules, which are comparatively brief and few in number, convey no idea of the amount of work involved in their specification and the many objections and difficulties that had to be overcome. The Society does not present this code as a perfected instrument; it is expected that as its provisions are put in force the necessity for further changes and improvements will be obvious, and experience will teach of other needs and the ways of meeting them. However, this code is the farthest step forward in the matter of Lighting Legislation; it has served as the basis of every state code at present operating, and in some states the code has been adopted in its entirety. The code and a discussion of its significance and application will be found in an article by Mr. H. E. Mahan on page 110.

In conclusion, it is of interest to note that if the establishment of the state codes should have no greater effect than to teach manufacturers to keep lamps, glassware, and reflectors systematically cleaned the gain in useful light would be of the order of from 20 to 30 per cent.

Measurement of the Crest Values of Alternating Voltage by the Kenotron, Condenser, and Voltmeter

By J. R. Craighead

Standardizing Laboratory, General Electric Company

The very ingenious arrangement of kenotron, condenser, and voltmeter, which has been developed for measuring the crest values of alternating voltage and which is described in the following article, embodies in one instrument a *combination* of good qualities not possessed by previous devices for the purpose, among which may be named the oscillograph, spark gap, etc. The theory and construction of the crest meter, as it is called, is fully described below, the test of its accuracy recorded, and its advantages and limitations set forth.—Editor.

When insulation is subjected to an alternating high potential at commercial frequency in testing its dielectric strength, the stress tending to break it down is approximately proportional to the crest value of the potential wave applied. This fact has been recognized for a number of years, but the difficulty of securing a measurement of the crest value during an actual test has induced the use of various alternative measurements in practical work. These have caused trouble because the ordinary variation of wave form to be expected in this work is sufficient to cause unexpected breakdown unless the voltages applied are based directly on a measurement of the crest value.

The Standardization Rules of the American Institute of Electrical Engineers prescribe that where the apparatus to be tested draws only a small current in comparison with the size of the testing apparatus, so that change of wave form from the no-load condition to the testing condition is negligible, the crest value of voltage may be determined under no-load conditions before the test. This is done by comparing the indication of an ordinary voltmeter, reading effective values, with the arcing point of a needle gap or a sphere gap. The voltmeter indication thus obtained is then used to hold the correct voltage during the test. Where the apparatus to be tested draws a large capacity current from the testing outfit, so there is danger that the wave form during the test may differ from that at no load, the rule requires that the crest value of voltage be measured under the actual testing condition.

Important tests of large generators, installed cable systems, etc., usually come under the second class. The rule may be followed by connecting all the apparatus as for the final test with a sphere gap or needle gap set for the value of voltage required for the test, increasing the voltage gradually until the gap arcs, and then removing it. The voltmeter reading just previous to the arcing of the gap is then held in the actual test. This method, however, during the preliminary checking, subjects the apparatus tested to the stresses caused by the arc in addition to those caused by the prescribed testing voltage. Even with the prescribed resistance of one ohm per volt in series with the gap, the apparatus tested may be subjected to stresses greater than those for which it was designed, and unnecessary breakdown may result. As stated above, it is precisely in the cases of the largest apparatus, where failure means the most in cost and in delay, that the crest voltage must be measured under testing conditions and the accompanying risks taken.

Several methods have been proposed for determining the crest value of voltage during the actual test without additionally stressing the apparatus tested, and some of them have been used with more or less success. The method here described is based on an invention of Dr. Clayton H. Sharpe. It has been found simple, accurate, and satisfactory under the ordinary conditions of insulation

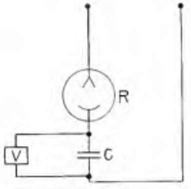


Fig. 1. Theoretical Circuit of Rectifier, Condenser, and Voltmeter

testing. It puts no unnecessary stress on the insulation. Apparatus has been developed to cover the voltage range ordinarily used.

The principle of this method of measurement is simple, the arrangement being diagrammatically shown in Fig. 1. If a perfect rectifier *K* of the electric valve type, which operates by allowing a flow of current in one direction but not in the other, is connected to charge a zero-loss condenser *C* without leakage, current will flow into the condenser during the first quarter cycle of voltage, the charge in the condenser increasing until the difference of potential between its plates equals the crest value of the voltage wave. The condenser plates then remain at the same difference of potential, reversed flow of current from the condenser being prevented by the rectifier. If any later crest of the same polarity rises above the potential of the condenser, more current flows to the condenser, the difference of potential between the plates after any period corresponding to the highest crest of voltage applied in the direction (which may for convenience be termed positive) in which current will flow through the rectifier. If a voltmeter which does not draw current is connected across the condenser, it will therefore indicate the highest value of positive crest voltage which occurs during the test.

In the application of this method to actual apparatus, several points must be considered. These may be summed up as: (1) internal voltage or voltage drop in the rectifier, which alters the voltage applied to the condenser; and (2) leakage.

The first item is dependent on the character of the rectifier and the connections, and will be discussed later in connection with the specific devices used. The second item is present in all apparatus, and the amount of leakage allowable depends on the purpose for which the outfit is to be used.

If a record is desired of the values of single crests of voltage of very short duration, as in attempting to obtain the value of the first crest in a voltage wave train which decreases rapidly, the leakage must be practically zero—say of the order which diminishes the condenser charge not more than one per cent per second. With a greater leakage, the instrument either does not reach the maximum indication, or recedes from it too rapidly for a reasonable reading. The capacity of the condenser must also be small enough to allow complete charging during the rise of the wave to crest voltage without causing drop in the rectifier by the amount of current drawn to the condenser. Since the condenser must be charged in a very short time, the momentary value of current which causes drop in voltage is comparatively high; the instrument has not yet been successfully used for this work.

For ordinary purposes some leakage is desirable. Since the instrument should ordinarily indicate the average value of several crests immediately past, any tendency to retain a higher reading is to be avoided. Hence, the leakage should be sufficient to allow the instrument to change from a higher to a lower reading promptly, but not sufficient to bring the average voltage of the condenser appreciably below the maximum. For a 60-cycle circuit, a leakage which lowers the condenser voltage at least three per cent per second is required to follow the usual fluctuations satisfactorily. The maximum allowable leakage depends on the nature of the rectifier, the capacity of the condenser, and the other devices in circuit.

The kenotron was found the most satisfactory rectifier for this service. It has the desired characteristic of ability to stand high voltages with very little leakage, and the internal drop and losses at the low current values required are small.

The kenotron consists of a glass bulb, evacuated to a nearly perfect vacuum, containing an anode, and a cathode whose temperature can be controlled by passing current from a low-voltage source through it. At high temperature the cathode emits negatively charged corpuscles known as electrons. If under this condition a voltage is applied across the terminals, the electrons emitted from the cathode receive an acceleration due to the electrostatic field. If the anode is negative to the cathode, this action causes the negative electrons to be repelled from the anode, and consequently no current can pass. If the anode is positive to the cathode, the electrons are caused to travel to the anode, and a current will flow which cannot exceed that represented by the total electrons emitted from the cathode at that temperature.

Two causes may affect the voltage delivered by the kenotron: (1) the initial velocity of the electrons emitted from the hot cathode; and (2) the drop in the cathode filament due to the flow of current used to maintain its temperature. The first item is of the order of one volt under ordinary circumstances and tends to increase the instrument reading.

The second depends on the voltage for which the cathode heating circuit is designed, but is usually five or six volts and tends to diminish the instrument reading. Where the excitation current is from a battery, the drop in the cathode does not affect the result (for very small currents) if the negative side of the battery is connected to the junction of the cathode filament with the alternating-current line as shown in Fig. 2.

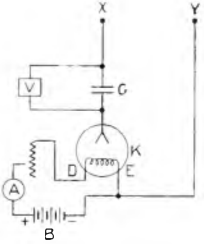


Fig. 2. Crest Voltmeter Circuit using Kenotron, Condenser, and Voltmeter

The reason for this phenomenon may be explained as follows:

At the time of passage of current, the anode is positive to the cathode. The end of the cathode nearest the negative terminal of the battery will be at the greatest difference of potential from the (positive) anode, the other end of the cathode being at a higher potential by the amount of drop due to the battery current flowing through it, and consequently being nearer, and possibly above the anode potential. The electrons emitted from the cathode are attracted toward the anode, as long as the anode is positive to the cathode, but the greatest acceleration will be where the difference of potential between cathode and anode is greatest; that is at the end of the cathode connected to the negative side of the battery. As soon as the current begins to pass, the voltage across the kenotron gap is very small and all passage of current (if the current is kept small) is from the end of the cathode having the greatest difference of potential from the anode. Consequently, the drop of voltage in the cathode does not affect the voltage delivered. If the supply voltage to the cathode is reversed, so that the positive side of the battery meets the junction of the filament with the cathode line, the opposite end D of the cathode has the greatest difference of potential from the anode and the flow of current is through this end of the cathode. Under this condition, the voltage drop of the cathode DE is subtracted from the voltage applied at X and Y, so that the voltage read on the voltmeter V is decreased by this amount.

TABLE I

EFFECT OF LEAKAGE CURRENT ON READING OF CREST VOLTMETER

Effective Alternating-current Voltage	Calculated Crest Voltage	Crest Voltmeter Reading	Direct-current Amperes (Leakage)	Per Cent Crest Voltmeter Reads Low	Capacity mf.
507	717	555	0.00690	22.5	1.8
503	711	572	0.00440	19.0	1.8
500	707	622	0.00207	12.0	1.8
493	698	625	0.00125	10.5	1.8

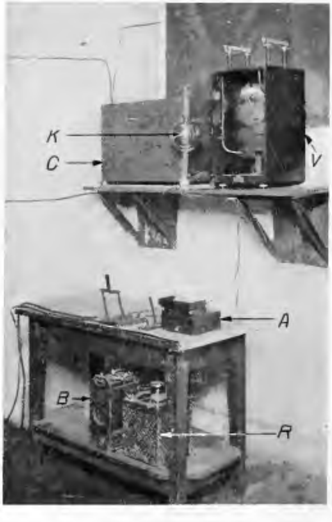


Fig. 3. Apparatus for Measuring Crest Voltage Direct
B, Battery; *R*, Control Resistance for Filament; *A*, Ammeter Indicating Filament Current; *K*, Kenotron; *C*, Condenser; *V*, Voltmeter

Table I shows the effect of the amount of leakage current on the reading of the crest voltmeter. A sine wave of voltage was used and the crest voltage calculated from this for comparison with the crest voltmeter. These tests were made at 60 cycles and the capacity was kept constant to show the results of varying leakage.

Fig. 3 shows an outfit arranged for reading direct the lower range of voltages used in high-potential testing. A condenser C consists of 29 glass plates with tinfoil coating, each capable of standing about 10,000 volts alternating current and each having a capacity of approximately 0.002 microfarads. These can be connected to give various combinations by means of clips. A standard electrostatic voltmeter is located at V. A 30,000-volt instrument is shown, a 50,000-volt instrument was used for voltages beyond the scale of this instrument, and 10,000- and 3000-volt instruments for lower ranges. The kenotron K is rated 50,000 volts (alternating current) and was used well within its limits of voltage. The battery B, resistance R, and ammeter A are used to supply and regulate the cathode current. Table II shows a comparison of the indications of this outfit with the calculated crest values when a sine wave of voltage was applied.

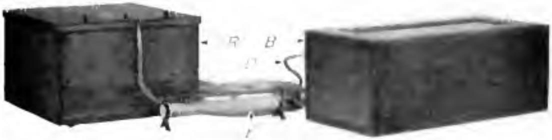


Fig. 4. Assembly of Apparatus for Measuring Crest Voltage from Volt Coil
B, Instrument Case; *D*, Cable to Resistance; *R*, Resistance Box; *E*, Filament Current Resistance

TABLE II
CALIBRATION OF KENOTRON, CONDENSER, AND ELECTROSTATIC VOLTMETER ON 60 CYCLES

Calculated Max. Voltage	Voltmeter and Kenotron Reading	Per Cent High (+) or Low (−)
6,990	6,925	0.93
6,990	6,925	0.93
22,830	22,650	0.79
24,100	23,900	0.83
28,030	27,200	2.9
34,100	27,780	18.4
34,380	27,800	19.2
34,900	28,600	18.0

These tests show that the reading of maximum voltage is satisfactory up to about 25,000 volts, and becomes rapidly worse above this point. The leakage is increased, probably due to corona formation on the condenser, and the resulting voltage [illegible] voltmeter is low.

A few checks were made to determine the availability of the outfit for [illegible] frequencies, and it was found that [illegible] were at least approximately correct. Table III shows a check at 120,000 cycles against a needle gap calibrated at 60 cycles.

For many cases, particularly in routine testing work, it is preferable to use an instrument which can be operated on the low-tension side from the volt coil usually made a part of the transformer winding for measurement purposes. For normal ranges of frequency and the usual wave distortions, the crest value of voltage measured on this coil will be related to the crest value on the high-tension side by the same ratio that

TABLE III
CREST VOLTAGE AT 120,000 CYCLES

Needle Gap	Crest Meter
2600	2660
2600	2750

Fig. 5. Instrument and Case of Apparatus for Measuring Crest Voltage from Volt Coil
V, Voltmeter; *K*, Kenotron; *C*, Condenser; *A*, Filament Current Ammeter; *S*, Scale Transfer Switch; *P*, Protective Switch

applies to effective values. An outfit consisting of kenotron, condenser, and low-voltage electrostatic voltmeter was tried for this purpose and found accurate; but the delicacy of the electrostatic voltmeter made it objectionable for regular testing work under shop conditions.

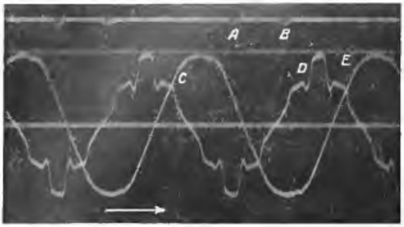


Fig. 6. Sine Wave and Distorted Wave Giving Same Indication on the Crest Voltmeter

An outfit was therefore developed in which the leakage current, instead of being kept at a minimum value, was used to operate a sensitive portable instrument of the permanent magnet type. This outfit was then standardized by actual test with a sine wave, and comparative tests were made on distorted waves to assure that the result is reliable within the ordinary variations of the testing wave.

This outfit is shown in Figs. 4 and 5. It is arranged for table mounting and is incased for protection against dust. Referring to Fig. 4, R is a resistance of seven megohms with a middle tap connected to the box B containing the kenotron, condenser switches, and instrument by the highly insulated lead-covered cable D. The resistance for controlling the filament current is shown at E. The battery is not shown.

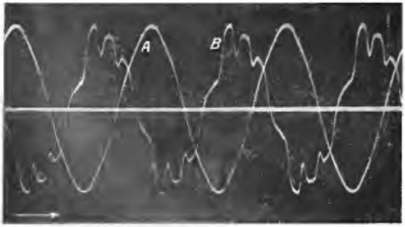


Fig. 7. Sine Wave and Distorted Wave Giving Same Indication on the Crest Voltmeter

Fig. 5 shows the arrangement within the box. A protective switch P cuts off one side of the voltage supply from the instrument when the top of the box is raised, to avoid danger due to handling the parts when alive. The other side of the voltage supply is grounded. The kenotron K is a low-voltage model, capable of standing 1000 volts alternating current. The ammeter A is used to hold the correct current at the cathode. The condenser C consists of four paraffined paper condensers in series, and has a capacity of about 0.225 microfarads. The voltmeter V is an extra sensitive portable instrument of the permanent magnet type, with scale marked 0 to 450 volts for use with 3.5 megohms series resistance. The switches S are arranged to connect 7, 3.5, or 1.75 megohms in series with the voltmeter giving full-scale readings of 900, 450, and 225 volts respectively. These scales give the effective voltage, corresponding on sine wave assumptions to the maximum actually applied to the outfit. This is for a more convenient comparison with the values given in the A.I.E.E. rules for standard spark gaps.

At full-scale deflection, the voltmeter draws approximately 180 microamperes (180×10^{-6} amperes). While this current is not enough to cause serious voltage drop under regular testing conditions, the instrument scale has been determined by holding actual alternating voltage of good sine wave form on the apparatus and observing the deflection of the pointer. This was done with the 3.5 megohm connection (450-volt scale) and comparative checks were made on the other connections.

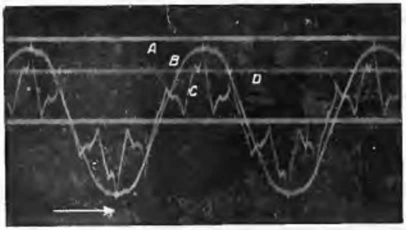


Fig. 8. Sine Wave and Distorted Wave Giving Same Indication on the Crest Voltmeter

This outfit is intended for use on ordinary high-potential tests, where the introduction of extremely high harmonics or sharp peaks of voltage is improbable. To show its performance with changes of wave shape, oscillograms were taken of different voltage waves applied to the outfit, while holding the same deflection on the crest meter. Fig. 6 shows a good sine wave *C* and a distorted wave *D* obtained while holding equal deflections on the crest meter. The maxima are equal, showing that the meter when calibrated on the sine wave reads the maximum of the distorted wave correctly. The effective value of the sine wave is 393 volts and of the distorted wave 317 volts.

The current drawn to the kenotron is *A* while the distorted wave is applied, and *B* while the sine wave is applied. The calibration of the kenotron current value is *E*.

Fig. 7 shows another form of distorted wave *B* compared with the approximate sine wave *A*. The crest values obtained by holding the same point in the two cases on the crest meter are equal. The effective value of the sine wave is 201 volts, and of the distorted wave 182.5 volts.

Fig. 8 shows a comparison between a sine wave *B* and a wave with extremely sharp peak *C*. Here the crest value of the distorted wave is approximately four per cent higher than that of the sine wave when holding a similar deflection on the crest meter. This distortion shows the condition at which appreciable error appears in the indication of the crest meter. As this distortion is far in excess of that normal to insulation testing at high potential, the instrument will evidently serve its purpose for the usual testing conditions.

In this oscillogram, it may be noted that the crest of the distorted wave is appreciably lower in the half cycle when the current flows to the kenotron than in the half cycle during which no current flows. The current is comparatively large because of the rapid change of voltage just before the crest value is reached, and this current [illegible] through the impedance of the [illegible] In such cases, therefore, there [illegible] crest of the opposite polarity [illegible] recorded by the outfit. This [illegible] avoided by the use of a second kenotron [illegible] to draw a similar current from the half waves of opposite polarity, thus duplicating the effect on the opposite crest. This has been found unnecessary in the present outfit.

Summary

The new apparatus will measure satisfactorily the crest value of the ordinary wave used in testing insulation at high potential directly up to about 25,000 volts, and indirectly by means of a volt coil up to any limit for which suitable transformers are available. No unnecessary stress is applied to the insulation by the use of the crest meter.

Approximate measurements may be made up to frequencies of 120,000 cycles with the kenotron and electrostatic voltmeter. On extremely sharply peaked waves, the kenotron with portable direct-current voltmeter records a crest value a small percentage low.

Neither apparatus as yet assembled is satisfactory for the measurement of single voltage crests of extremely short period although with suitable development it is probable that this measurement may also be made.

REFERENCES

"A New Device for Rectifying High-tension Alternating Currents," by Dr. Saul Dushman. GENERAL ELECTRIC REVIEW, March 1915, p. 156.

"Crest Voltmeters," by C. A. Sharpe and E. D. Doyle; "The Crest Voltmeter," by L. W. Chubb; "The Voltmeter Coil in Testing Transformers," by A. B. Hendricks, Jr.; "Notes on the Measurement of High Voltage," by William R. Work; all in *Transactions of the A.I.E.E.* 1916. Vol. XXXV, pp. 99 to 146.

Lighting Legislation

By H. E. Mahan

Illuminating Engineering Laboratory, General Electric Company

The Illuminating Engineering Society has given a great deal of thought to the question of legislation regulating lighting in industrial plants, and after a great deal of study, deliberation, and discussion, a set of requirements have been drafted for presentation to the several state legislatures for their consideration and guidance in enacting laws on this subject. These rules, or recommendations, are given in this article and the significance of each is pointed out and discussed.—**Editor.**

Welfare work and safety engineering are today occupying an important place on the roster of the industrial manager. This is partly the result of a realization by industry that its efforts in this direction are a real asset and partly because of the interest taken in behalf of the workman by the State as evidenced by employees' compensation acts and various codes for safeguarding the health and limb of the workers. One of the most recent additions to the list of state codes for the welfare and protection of industrial workers is that covering lighting. It is entirely logical that lighting should be added to the list of subjects considered necessary for state control, as statistics* show that 23.8 per cent of all industrial accidents are due directly or indirectly to improper lighting. If this loss in productive labor may be only partially reduced, it will be a great advance step in the interest of human conservation.

The larger and more progressive manufacturers have not been slow to recognize the advantages of proper and adequate lighting, but the less efficiently operated plants, sweat shops, etc., are still in ignorance regarding its beneficial influence. It is to these backward shops and factories that the lighting codes are addressed, and it is they that are destined to learn that correct lighting is a good investment both as a factor in economic production and in remunerative welfare work.

The question of lighting legislation has been studied for many years by the Illuminating Engineering Society through its Committee on Lighting Legislation. This society has actively advocated the adoption of its "Code of Lighting Factories, Mills, and Other Work Places," by the industrial commissions of the several states, and as a result of the efforts this code forms the basis for every state code at present operative; in fact, some of the states have adopted it in its entirety. Mr. G. H. Stickney, while president of the Illuminating Engineering Society, in addressing the Pennsylvania and New Jersey inspectors at the University of Pennsylvania said in part as follows:

"No one who has not seen the growth of the code can realize how much effort has been exerted, and how many difficulties have been overcome, in producing the comparatively brief rules which you have before you. Many conferences of the Committee on Factory Lighting and the Committee on Lighting Legislation brought out new points of view and many changes. A meeting with the American Society of Mechanical Engineers in New York developed improvements, as did a meeting in Philadelphia. The Philadelphia meeting accomplished the very important effect of interesting Commissioners of Labor of Pennsylvania and New Jersey, and resulted in the movement to adopt the code in those states. The representatives of the Pennsylvania and New Jersey commissions gave much information especially as regards the matter of practical application and enforcement.

"We do not look upon the code as a perfected instrument. We expect to see further changes and improvements. We are all too conscious of its limitations. We expect to learn more about the needs and the ways of meeting them. Remember that industry is changing; illuminants are being improved.

"Some of the specifications are not so definite as we would wish, especially that regarding glare. But in codes, as in machinery, there comes a time in development when efficient progress can be made only by putting them in practical use. The same thing is true of the laws on the statute books; we provide legislatures to keep developing the laws.

"It is not the province of these codes to enforce the most efficient or most effective lighting. They can only demand such provisions as will reasonably insure the necessary welfare of workers by preventing accidents and eyestrain. This has been one of the embarrassing features of the problems to us as illuminating engineers. The limits set are far below what we consider desirable practice, and we would not as engineers recommend a manufacturer to adopt so low a standard. In general, the requirements are so low that a manufacturer is not justified in equivocating about the class in which a particular process falls. His own best economy will be served by adopting a higher class. Do not let him make the mistake of confusing glare with 'over-lighting.'"

---

* R. E. Simpson, Illuminating Engineering Society Transactions, 1915.

The similarity of the various state codes with the code adopted by the Illuminating Engineering Society is apparent from Table I and enables one to obtain a general idea of the whole field by a study of the Society's code. These rules as suggested by the Illuminating Engineering Society together with a brief discussion of them follow.

RULE 1. GENERAL REQUIREMENT. Working or traversed spaces in buildings or grounds shall be supplied during the time of use with artificial light in accordance with the following rules when natural light is less than the intensities specified in Rule 2.

This rule assumes that working spaces and grounds, and spaces which employees are compelled to traverse, are potential sources of accident if not adequately lighted, and requires that such areas be illuminated in accordance with the intensity rule. Natural light is made the basis for defining the time when artificial light is to be used, but it is not entirely satisfactory as a definite relation has never been established between the visional effectiveness of artificial light and natural light. Experience has shown, however, that the eye requires a higher intensity of illumination in daylight than in artificial light, and the latter is usually used before the former falls to two or three times the intensity required for artificial light. This rule has been almost universally adopted by the States at present [illegible] code in force.

RULE 2. INTENSITY [illegible] (See Table I).

The foot-candle intensity [illegible] in the past has been to a greater [illegible] the only standard by which a [illegible] has been judged. This idea is rapidly being dispelled by reason of the educational efforts of the lighting industry, and distribution, glare, etc., are being recognized as equally important factors. Many plants [illegible] with the intensity rule are found to be violating these other requirements and consequently are required to modify their lighting to conform to the code. It is, therefore, well to be cautious in studying these lighting codes and not attribute too much importance to the intensity clause to the exclusion of the others. Intensity is extremely important but its effect may be entirely annulled by failure to observe the other rules.

The intensity of light required for any operation depends upon the fineness of detail to be observed and the color of the material. For example, an engraver requires a higher intensity than a carpenter and a worker on dark textiles must have more light than one working on light colored goods. It is these varying requirements that make it very difficult to specifically state what

TABLE I

ILLUMINATION INTENSITIES

Foot-candles

	Nature of Subject	Illuminating Engineering Society	Wisconsin	Pennsylvania	New Jersey	New York
1.	Roadways and yard thoroughfares	0.02	0.02	0.02	0.02	0.02
2.	Storage spaces	0.25	0.25	0.25	0.25	0.25
3.	Stairways, passageways, aisles	0.25	0.25	0.25	0.25	0.25
4.	Toilets and washrooms		0.50			0.50
5.	Work not requiring discrimination of detail; such as handling material of coarse nature and performing operations not requiring close visual application					0.50
6.	Rough manufacturing requiring discrimination of detail; such as rough machining, rough assembling, rough bench work, also work in basements of mercantile establishments requiring discrimination of detail					1.00
7.	Rough manufacturing such as rough machining, rough assembling, rough bench work	1.25	1.25	1.25	1.25	
8.	Rough manufacturing involving closer discrimination of detail	2.00	2.00	2.00	2.00	2.00
9.	Fine manufacturing such as fine lathe work, pattern and tool making, light colored textiles	3.00	3.00	3.00	3.00	3.00
10.	Special cases of fine work such as watch making, engraving, drafting, dark colored textiles	5.00	5.00	5.00	5.00	5.00
11.	Office work such as accounting, typewriting, etc.	3.00	3.00	3.00	3.00	3.00

intensity of light should be required for any particular operation or machine. In a textile mill, obviously a machine may be working on light goods today and dark goods tomorrow and similarly a lathe may have a turning operation followed by a boring operation; each of which processes requires a different intensity of light.

New York State has inaugurated a new departure from previous codes in that a more detailed classification of industry is made and a minimum allowable intensity specified. This part of the code is at present tentative in order that manufacturers may have an opportunity to check the requirements and submit their criticisms. It becomes mandatory on July 1, 1919. Manufacturers are urged to co-operate in this matter and while a vast amount of field work has already been done by the industrial commission, the job is a big one and any further data bearing on the subject will gladly be given consideration by the state.

A portable photometer suitable for making field measurements is shown in Fig. 1. This instrument is self-contained, simple to operate, and has a range of from 0 to 15 foot-candles. It has been designed to meet the needs of inspectors and manufacturers in checking their lighting intensities.

RULE 3. SHADING OF LAMPS. Lamps shall be suitably shaded to minimize glare.

> *Note.—Glare, either from lamps or from unduly bright reflecting surfaces, produces eyestrain and increases accident hazard.*

Glare, unquestionably, is responsible for more unsatisfactory and dangerous lighting than any other single factor. It is also the most difficult to define in terms which are usable to the practical inspector and manufacturer. Glare is sometimes defined as light out of place; for example, a lamp exposed to the eye so as to create a relatively bright source compared to its surroundings or the reflection of a bright source from a glossy surface. The purpose of the rule is to protect workers from being compelled to view excessively bright areas either from the lamp itself or its image. The remedy is usually a matter of equipping lamps with reflectors, diffusing glassware, or raising them above the line of vision. The elimination of objectionable glare not only conserves eyesight but makes for more efficient workmanship.

An attempt has been made by some of the states to define the conditions which will be regarded as objectionable glare in terms of height of unit above floor, intrinsic brightness of source, etc. In the last analysis, however, it rests upon the inspector to decide by observation whether a condition of objectionable glare exists.

RULE 4. DISTRIBUTION OF LIGHT ON WORK. Lamps shall be so installed in regard to height, spacing, reflectors, or other accessories as to secure a good distribution of light on the work, avoiding objectionable shadows and sharp contrasts of intensity.

There are many dangers lurking in dark shadows and it is the purpose of this rule to minimize the possibility of workers falling into moving machinery or through trap doors, etc., that are made invisible by shadows. A sharp contrast in intensity will create the same effect as a shadow, for the eye accommodates itself to the brightest field in view and, in closing up to exclude harmful intensities, the less brightly illuminated areas appear dark. A worker turning from a brightly lighted area to a relatively dark area is momentarily blinded and, therefore, susceptible to accidents.

It is also important to have light on the plane on which work is to be done; for example, a clerk working on a flat desk requires light on a horizontal plane, whereas a machinist working on a lathe boring operation requires a high vertical component of illumination. The purpose of this rule is to insure light being provided where needed for convenience in working.

RULE 5. EMERGENCY LIGHTING. Emergency lamps shall be provided in all work space aisles, stairways, passageways, and exits to provide for reliable operation when, through accident or other cause, the regular lighting is extinguished. Such lamps shall be in operation concurrently with the regular lighting and independent thereof. (I.E.S.)

This rule is self explanatory and endeavors to insure sufficient light being available in a building to enable the occupants to see their way around and to the exits in case of failure of the regular lighting system. It is difficult in many instances to comply with the requirement that the emergency system be independent of the regular lighting system, but a liberal interpretation is placed on this rule by the commissions, and in the case of electric service it is satisfactory if the emergency system be fed from an independent transformer in the street.

RULE 6. SWITCHING AND CONTROLLING APPARATUS. Switching or controlling apparatus shall be so placed that a *least pilot or night light, may be turned on at the main points of entrance.*

This rule aims to make it possible for the last person out of a building to have light up to the point of exit. It undoubtedly is a desirable rule, but some of the states, feeling that it would place an unnecessary hardship upon manufacturers whose plants are already equipped, have modified or omitted the requirement. A system complying with this rule enables a watchman to have the lights on in a building as he passes through it; but it is maintained by many plant managers that this is undesirable as the principal function of a watchman is to detect fire, which, of course, may be more readily done if the building is dark.

Realizing that few [illegible] practice are responsible [illegible] system, all the states have published general to their codes, in which are included data and information on lighting. It is, of course, not the state's prerogative to demand of a manufacturer that he operate his plant in the most efficient manner. This is a matter for individual managers to concern themselves with, but the state is vitally interested in the welfare of its citizen workers. It must be remembered, therefore, that the illumination requirements specified in these codes are not for efficiency in plant operation but for the safeguarding of the eyesight and health of industrial workers.

Electricity in the Ceramic Arts

By J. P. Alexander
General Electric Company

Until recent years, electricity had not been introduced into pottery and tile-making factories for the reason that it had been generally supposed that a steam engine, by reason of the excess power it could produce over its normal rating, was the only driver that could start up the machinery after the clay had settled in the mixing tubs overnight. Recent electrical installations have shown the fallacy of this idea, and have proved to ceramic engineers that the electric motor can duplicate any of the engine drives. In the following article, containing descriptions of the various processes employed in the pottery industry, etc., the service afforded by electricity in this field is well outlined. The service of electricity in other branches of chemical and allied industries was treated in "Electricity Releases Chemistry's Power," by J. M. Matthews, General Electric Review, November 1918, page 727.—Editor.

Until recent years, electricity had not been introduced into pottery and tile-making factories for the reason that it had been generally supposed that a steam engine, by reason of the excess power it could produce over its normal rating, was the only driver that could start up the machinery after the clay had settled in the mixing tubs overnight. Recent installations have shown the fallacy of this idea, and have proved to steam engineers that the electric motor can duplicate any of the engine drives.

The machinery to be driven in the pottery, tile making, and allied industries and the power requirements are itemized in Table I. In addition to the apparatus listed there is occasion to use, in the same class of industries, complete machine shop equipments where dies and molds are made (5 to 20 h.p.), and elevators for the handling of wares (3 to 15 h.p.), and also for the handling of coal for kilns (motor-operated hoists on trolley rails).

At this writing, no electricity has been utilized for the drying of or the firing of wares, although experiments are being projected at present; the problem of drying the wares is the first that is receiving consideration. Continuous dryers utilizing motors, heating coils, and ventilating fans for producing the drying with proper humidifying of the air to prevent the cracking or warping of wares, are now offered for sale by several manufacturers.

The power required in average potteries varies from 50 h.p. upward; and up to this time electricity has been furnished mainly as direct current. At present, however, alternating current has been introduced into potteries and tile works with great success, the principal reduction in operating costs occurring in the slip rooms where clay is prepared for working. The saving is the result mainly of the improvements made in the machinery used extensively heretofore. Most of these improvements have occurred during the last three years and have affected the drives.

In such plants the clay is usually unloaded by hand from cars. It is then thoroughly mixed and wetted, the crushing being done either in the dry or wet state. The clay is thrown into a blunger with ground flint and spar where it is thoroughly mixed by revolving arms until it produces a thin mud or slip which varies in color according to the kind of clay used and the wares to be produced. Several different varieties of clay are used for making up the body material.

Plants which do their own grinding of some materials claim that uniformity of ware comes from grinding particles always to the same sizes. Such grinding, when conducted

TABLE I

Machine	Horse Power
Dry pans	7½ to 15
Dry grinding mills	5 to 15
Mixing tanks	2 to 5
Slip pumps	3 to 5
Stirring tanks	½ to 5
Blungers	5 to 10
Lawns	2 to 5
Generators for furnishing current for slip magnets to extract iron from clay	½ to 3
Wad mills	3 to 7½
Pug mills	5 to 14
Sagger presses	2 to 7½
Tumbling drums	1 to 10
Emery wheels	½ to 5
Special wet grinding machines for grinding wares by laying them on traveling tables covered with sand for the grinding agent, the table being actuated and the wares held by stationary barriers	5 to 50
Milling machines for milling sanitary earthenware in quantity	5 to 50
Jiggers	½ to 3
Electric finishing machines	¼ to 1
Vertical grinders	¼ to 1
Exhaust fans and vacuum cleaners	1 to 20
Ventilating fans	¼ to 10

wet or dry, furnishes an excellent central station load that enables the usual power rate (based on a sliding scale) to be made more attractive than in plants where such grinding is not carried on.

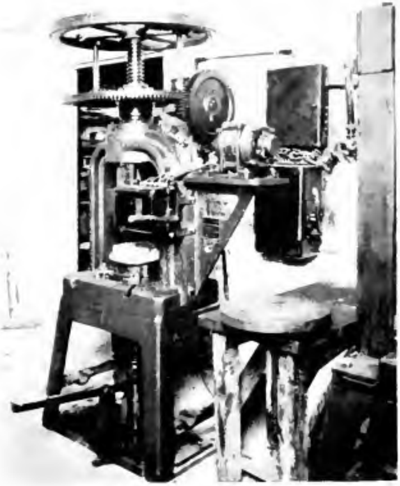
After the slip has been thoroughly mixed it is allowed to drain off into large tanks usually located beneath the floor of the slip room. A shaft, carrying arms which revolve, passes down into this stirring tank. Electromagnets remove from the slip the iron that would otherwise spot the ware. This special electromagnet is placed in a trough through which the slip pours. Also a small generator or motor-generator is required for this electromagnet. The slip is then pumped into a filter press consisting of 25 or 30 sections, each with a piece of filter cloth in between. The filter cloth serves to strain the clay from the water. After the clay has filled up the filter press, the slip is then diverted through a second filter press, the first being released and unloaded. A steam-driven filter pump will slow down as the filter pressure increases and the output of the press as well as the whole plant is usually lowered, due to the retarding effect of the filter pump on the small engine usually employed. This is noted in almost every average size pottery. The slip room processes are thus the "neck of the bottle" and the factory's production is lowered in proportion. There is no reason why many "slip" room processes cannot proceed on electric drive during night hours, and thus reduce the load factor of such plants and the consequent cost of operation. Separate motor drive would prevent any reduction of output caused by slowing down of shafting.

The clay is then either thrown into a moistening room where it is kept wet and ready for working or it is thrown immediately into a pug mill where it is additionally mixed and forced out into large wads which are about eight inches in diameter and which can, as they proceed from the machine, be cut into slabs about twelve to fifteen inches long. The main object of the pug mill is to mix the material thoroughly and at the same time expel all the air, giving a solid character to the material. In this condition, the clay is ready for working and is usually moist enough for immediate service. If to be worked at once, it is carried into the pottery room where the potters begin to shape it into various utensils or wares. In the manufacture of china ware, the clay is placed on potters' wheels where it is turned into plates, cups, saucers, or any kind of round ware. In other cases, the clay in this condition is pressed into molds and turned into various shapes that cannot be made either on turning lathes or potters' wheels or jiggers. In some instances, the consistency of the clay must be very thin and in such cases the prepared clay is thinned down to a condition where it is poured into plaster-of-paris molds, the molds taking up the excess moisture and allowing the clay vessel, after a time, to be removed from the mold and set up to dry. In any kind of pottery, the drying process consumes from one to two days' baking in a temperature of about 85 to 90 deg. F., sometimes as high as 105 deg. F. Decorating kilns, which require 900 to 1300 deg. F., are well within range of the electric oven, which is sure to be put into use soon for such work.

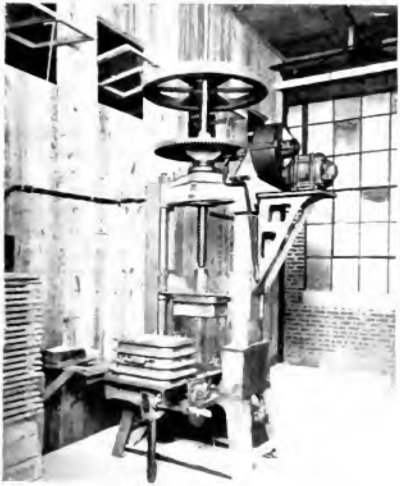
As soon as the drying is thoroughly accomplished the ware is ready for its first burning, which usually takes place as soon as the ware can be packed properly for protection against kiln smoke. At this point some wares can be glazed and finished in one firing; other wares require careful firing, covering from forty-eight to seventy-two hours at a temperature up to 2300 deg. F., the glaze being put on by dipping cold and a subsequent burning being given in other kilns where the temperature is high for a shorter period, the idea being to bring the

10-h.p., 1200-r.p.m. Induction Motor Operating a Crossley Machine Company's Glaze Drum, Lennox, Inc., Trenton, N. J.

7½-h.p., 900-r.p.m. Induction Motor Operating a Mueller Company's Pug Mill, Imperial Porcelain Company, Manasquan, N. J.



3-h.p., 1200-r.p.m., Reversible Induction Motor Operating a Mueller Machine Company's "Segger" Press, Lennox, Inc., Trenton, N. J.



3-h.p., 1800-r.p.m., Induction Motor Operating a Mueller Machine Company's "Segger" Press with Mechanical Reverser, Imperial Porcelain Co., Manasquan, N. J.

ware to a condition where the glaze will melt. If the ware is to be decorated, a third firing is often necessary; this will not reach more than 1500 deg. F. which is just sufficient to set the paint or color that is put on the wares over the glaze.

In order to burn the ware, and at the same time to protect it from kiln smoke, it is necessary to pack the ware in boxes of clay which are known as saggers. These boxes have until late years been made by hand and had to be constructed of fire-resisting clay which will withstand heat far beyond that of the clays burned. The breakage in the saggers is great, due to the high heats they must stand directly, which requires regrinding and mixing with fresh clay to be used over and over again. The motor drive of sagger presses has increased the output of these machines from 400 to 1000 per cent over hand operation. Various types of motors have been utilized for sagger presses, some driving and reversing by belt shifting and others furnishing a rapid reversing service direct.

The individual motor drive application to jiggers has increased the plate, cup, and saucer production about 30 per cent over the previous method of drive.

The average load factor that is required on the mechanically operated machines in potteries and tile industries is usually about 40 per cent of the total load of the machines (10 hours a day basis), this load factor rising in direct proportion as the machines are operating full time. The load in such plants can, by careful analysis, be so arranged as to produce a practically constant load factor all day on a 24-hour-a-day basis. It is consequently an ideal load for a central station.

The porcelain industry, pressing for the most part from dry clay, departs to some extent from the method of manufacture just described. It uses dry grinders for the preparation of clay, and the porcelain work is done mainly by hand-operated presses, but there are several motor-driven presses which promise to be satisfactory for such work. It is claimed that there are no mechanical considerations to prevent electrically driven presses turning out wares from dry dust, and the results confirm this opinion.

There appears to be a great opportunity in the porcelain industry for drying saggers and firing kilns electrically. These problems will, no doubt, be also taken up as rapidly as ingenuity and opportunity permit.

The pyrovolter and other forms of pyrometers are now used extensively in research experiments and in drying rooms and kilns for the indication of temperatures.

The same process of manufacture that has been described in connection with the china ware industry holds good in connection with the sanitary earthenware industry, except that in the latter the pieces are usually larger and are more intricate in design; and at the same time require all the potter's skill both in the manufacture and in the glazing and firing. Hand labor and experience are very much required in this industry and up to this time mechanical methods for producing salable sanitary earthenware goods have not been very successful, though worthy of continued effort. These wares are molded or built up by hand.

The making of bath tubs has been extremely hard to reduce to a mechanical process as the clay has to be worked wet and requires unusual skill in drying out, preparatory to firing. Also the firing of bath tubs and sanitary earthenware carries with it a high percentage of breakage and the losses are sometimes very great.

Efforts are now being made to control the drying by electric coils placed inside of hollow parts of the ware to cause shrinkage in some directions where otherwise it would not occur to the satisfaction of the operative. It is expected that electric current will be of considerable advantage in such work.

One company uses electric finishing machines, and has an extensive vacuum-cleaner equipment which contributes materially to the healthful conditions of the works. State factory inspectors also are requiring more attention to hygienic ventilation.

It can readily be seen that much skill and experience is necessary for the turning out of fine wares, as there are so many points to be considered in design and treatment to prevent the unequal expansion and consequent breakage. It may be said in general that the art can be constantly improved so far as mechanical methods of manufacture are concerned, but marked advances have to be made in the design, the chemistry, and the technic of the art to allow machinery to replace the skilled hands required.

It will be of interest to note that, since the war began, American clays have come extensively into use and are given the necessary refining to produce the same quality of ware as has heretofore been made from foreign ball clays.

Speed Control of Induction Motors on Cranes and Hoists by Means of Solenoid Load Brakes

By R. H. McLain and H. H. Vernon

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A few years ago practically all crane hoists were equipped with automatic mechanical load brakes; today a very large number of cranes equipped with direct-current motors use dynamic braking instead. The development of the solenoid load brake for alternating-current wound rotor motors makes possible the elimination on an alternating-current crane hoist of the more or less troublesome mechanical load brake. Practically the same speed-torque characteristics obtain with an alternating-current motor equipped with a solenoid load brake as with a direct-current motor with dynamic braking. This article covers different applications of solenoid brakes and gives a detailed description of a solenoid load brake.—Editor.

For stopping machinery, holding machinery and lowering loads, some form of braking is required. Two general classes of braking are in practical use. The first is friction braking, which makes use of a smooth brake wheel against which is applied stationary shoes or a band. The force for applying these stationary shoes or band in practice is derived from hand power, air power, steam power, oil power, solenoid power, or motor power.

A very familiar form of brake which is used for lowering motion is called an automatic mechanical load brake. Until recently this was used on the hoist motion of all alternating-current cranes except a few small or slow speed cranes. It is a device which acts as a solid coupling when the load is being hoisted, but when the load is being lowered some pawls drop into place and cause the device to act as a friction brake. Therefore, the motor is required to exert a small amount of torque in the lowering direction in order to unlock the device and permit the load to be lowered.

The second is electrical braking, of which there are three kinds in common use, viz., back torque or "plugging," dynamic braking, and regenerative braking. With back torque or "plugging," power from the supply system is consumed for lowering and stopping a load. With dynamic braking the moving body generates electrical power which is dissipated in a rheostat. This type of braking can be used for retarding machinery and lowering loads, but will not serve to bring a body absolutely to a standstill or to hold a load. With regenerative braking the moving body generates power which is returned to the power supply system. It is not possible to reduce the speed of the moving body to the same extent as with dynamic braking. Regenerative braking is principally useful for lowering loads.

The best practical results are ordinarily obtained by using a combination of some form of electrical braking and some form of friction braking. The principal advantages of electrical braking are accuracy of speed control and elimination of mechanical wear on the apparatus. The advantages of friction braking are that it can be used for accomplishing some results more economically and simply than can electrical braking, and that it can be used to hold the load at standstill without the consumption of electric power; also, it can be used, even when the power supply fails, as a safety device. One of the most convenient methods of operating friction brakes is by means of electric solenoids, because they are readily adapted to remote control and also serve as an automatic safety device in case of failure of power.

The use of solenoid brakes has been vastly extended due to their recent applications in connection with other forms of electric braking.

In the past, the claim has been made that a solenoid brake would give only one degree of torque, and that if this was not exactly suitable for the needs of the case, inferior operating results would be obtained, whereas hand- or air-operated brakes could produce a graduated braking which would in each case produce exactly the desired operating results. There is a whole lot of truth in the above claim, but a close analysis of the demands will show that only a small percentage of cases cannot be met by either a multiple magnet brake, which gives two degrees of braking, or a solenoid load brake, which gives a variable amount of braking responsive to the speed of the motor with which it is used.

It is the purpose of this article to describe these two kinds of solenoid brakes and point out some of the applications for which they are adapted.

The multiple magnet solenoid brake is, so far as operation is concerned, nothing more nor less than two solenoid brakes, but for convenience and economy it is made up in the form of one brake operated by two or more independent magnets. When both are energized the brake is entirely released, and the brake wheel is free to move. When one magnet is de-energized the brake is set and gives a fraction of the torque capacity of the brake. When a second magnet is de-energized additional torque is applied, and so on for as many magnets as may be used. The multiple magnet brake, having two magnets, is specially adapted for stopping apparatus which is moving in a horizontal plane, and some of its detailed uses are described below. In all these cases, if direct current were used it would be thoroughly practical to use dynamic braking in connection with a single torque solenoid brake to accomplish the desired results; and, if either alternating or direct current were used, it would be feasible to use back torque or plugging control in combination with a single torque solenoid brake. These last combinations would ordinarily not be warranted unless very big units were involved.

In the case of the revolving motion on a hammer head or locomotive crane, where there is some kind of flexible steel work used in the tower structure, and where there is a lot of lost motion in the gears, it is advantageous to apply a light amount of torque to take up all of the play in the gears and spring of the machinery, and after this to apply a heavier torque for bringing the machinery to rest at the desired rate of speed. This is true of all kinds of machinery where there is a lot of back lash in the gearing.

For traveling gantry cranes which are exposed at times to high wind pressures, it is frequently desirable to have a solenoid brake which will prevent the crane from being blown along the track. A brake which is powerful enough to exert this torque will be so powerful as to produce undue shock to the machinery in ordinary stopping when no wind is blowing. It is therefore advantageous to have one degree of braking, just sufficient to stop the gantry nicely and smoothly for ordinary purposes, and a second degree of braking which is powerful enough to hold the gantry against a strong wind.

Many moving bodies carry a swinging hook underneath them, and it is sometimes advantageous to use one degree of braking when a heavy load is on the hook and a lighter braking when a small load is on the hook, in order to stop the carriage as quickly as possible in all cases without unduly quick stops being made in some cases.

This system of braking can be controlled from a remote point in a number of different ways. First, both solenoids can be energized and de-energized simultaneously when power is applied to the motor, one of the solenoid cores being retarded from falling for a few seconds by means of a dashpot. In such a case, at the off position of the controller the brake will be set, and on the first step of the controller the brake will be entirely released. However, when the controller is thrown from the first step to the off position, a light torque will be applied first, and after a predetermined time full torque will be applied.

A second method is to so arrange that, at the off position of the controller both magnets are set. On the first step one of the solenoids is energized and the brake exerts only a partial torque. On the second step of the controller both solenoids are released and power is applied to the motor. This method is more universal in its adaptation than the first method, but requires more wires between the controller and the brake. It is also thoroughly feasible to use a dashpot with this scheme so as to eliminate the sudden application of full power of the brake in case power fails or in case the operator makes a careless or accidental motion with his controller.

The third method of controlling the brake is to arrange so that at the off position both solenoids are set. On the first step one solenoid is released; on the second step both solenoids are released; and on the third step power is applied to the motor. This does not differ from the second method, except that there is one step on the controller where neither power is applied to the motor nor braking is used. This coasting point is very economical with respect to the heating of motors, and also with respect to power consumption on high speed trolleys, such as man-trolleys on coal and ore bridges running at 600 feet per minute and higher. The operator will find it very convenient and economical to turn the controller to the coasting step after the trolley has been accelerated to full speed, thus allowing the trolley to coast. One advantage of two magnets on the brake of a high-speed trolley is that it assists the operator in spotting his carriage at a definite point. As he approaches the point of stopping he applies a small torque and brings the carriage to a low speed, allows it to drift on the coasting step to within a very short distance of the exact spot where it is to be stopped, when he produces full torque on the brake and brings the carriage to a very quick stop. This method of controlling the brakes has certain elements of danger connected with it which are not present in the first and second methods described. In the first and second methods it would be impossible for a wind to blow the machine away without either the motor exerting regenerative braking or the solenoid brake exerting friction braking, whereas this third method has a coasting step on which it would be possible for the controller to remain while a wind was causing the machine to attain a dangerously high speed. Therefore the third method should not be used on machines which are exposed to wind pressures capable of creating a dangerous condition.

Where many varieties of loads are to be lowered by the same hoist, it has been thought that the only practical way to handle these loads with friction brakes was by means of an automatic mechanical load brake, or hand- or air-operated brakes, so that a different value of braking torque could be used in handling every different value of load. However, when the requirements are analyzed it will be found that the actual demands are not for an infinite number of braking torques, but for an accurate speed control of the body which is being lowered, and that the ideal control must produce any desired speed regardless of what load is hanging on the hook; in other words, a braking arrangement which is so responsive to the speed that when the speed drops below a certain predetermined value all braking will be decreased automatically, whereas if the speed is above a certain predetermined value the braking will be increased automatically. This requirement has been met by what is called a solenoid load brake, for use with alternating-current induction motors. This brake consists essentially of an ordinary solenoid brake in which the solenoid is of such weight that very little braking action is obtained from the operating solenoid. This is designated (B) in Fig. 1. But in addition to this operating solenoid, there is a solenoid (A) which is connected to the circuits of the rotor. If this second solenoid (A) is de-energized, it applies heavier weight to the brake levers and consequently greater braking torque. If it is energized, its weight is almost raised from the levers and it exert practically no braking torque. At intermediate values of rotor voltage an intermediate amount of braking will be obtained. Now, since the voltage which is generated by the rotor of an induction motor varies directly as the slip of the motor, we obtain in such a brake the ideal characteristic, because when the motor is standing still a high voltage is induced in the rotor and consequently a small amount of braking would be obtained, whereas when the motor is running at high speed, a low voltage is induced in the rotor and consequently a greater amount of braking is obtained. Actual tests made on such a device show that there is sufficient resistance drop in the coil of the magnet and sufficient core loss in the iron to make the magnetic pull almost follow a straight line law between full speed of motor and standstill. Further remotely controlled regulation of the braking is obtained by connecting a resistor in series with the rotor circuits and the brake magnet, and by adjusting the value of this resistor through the controller. This resistor is shown as R_1 and R_2 in diagram 2. A still further variation in the amount of effective braking at the motor shaft can be obtained by adjusting the regular control resistor in the rotor circuit so that the motor itself pushes more or less against the friction brake. In other words, if a light load is to be lowered the motor can be made to produce a large torque, and if a heavy load is to be lowered the motor can be made to produce a small torque. The torque of the motor in each case is such as to drive the load downward, whereas the torque of the brake would be such as to prevent the load from being lowered. The combination of these methods, all controlled from one handle, makes it possible to obtain any desired speeds below synchronism on an induction motor. When it is desired to lower a load at or above the synchronous speed of the motor it is thoroughly practical and desirable to entirely release the solenoid brake and thus eliminate friction braking altogether, allowing the load to be lowered by regenerative braking. The brake is entirely released by energizing solenoid (B), Fig. 1. Therefore, in a practical case the load would be lowered almost to the bottom of travel by means of regenerative braking without any friction wear whatever, and then near the bottom of travel the solenoid load brake would be brought into operation so as to handle and land the load at low speed.

An alternating-current crane which is controlled by a solenoid load brake compares very favorably in operation with a direct-current crane which is controlled by means of dynamic braking and a solenoid brake. It might be said that from a friction wear standpoint, the solenoid load brake is intermediate in its advantages between an automatic mechanical load brake and a system of direct-current dynamic braking. With the automatic mechanical load brake there is friction wear throughout the whole of a lowering trip. There is also friction wear from stopping the load at the bottom. With the solenoid load brake there is no friction wear while lowering the load, but there is friction wear while stopping the load and while operating at creeping speeds for the purpose of landing a load. With direct current and dynamic braking there is no friction wear while lowering a load either at high speed or at creeping speed, and there is no friction wear when stopping a load except from something like 25 per cent of full speed down to standstill. This brake is relatively very small.

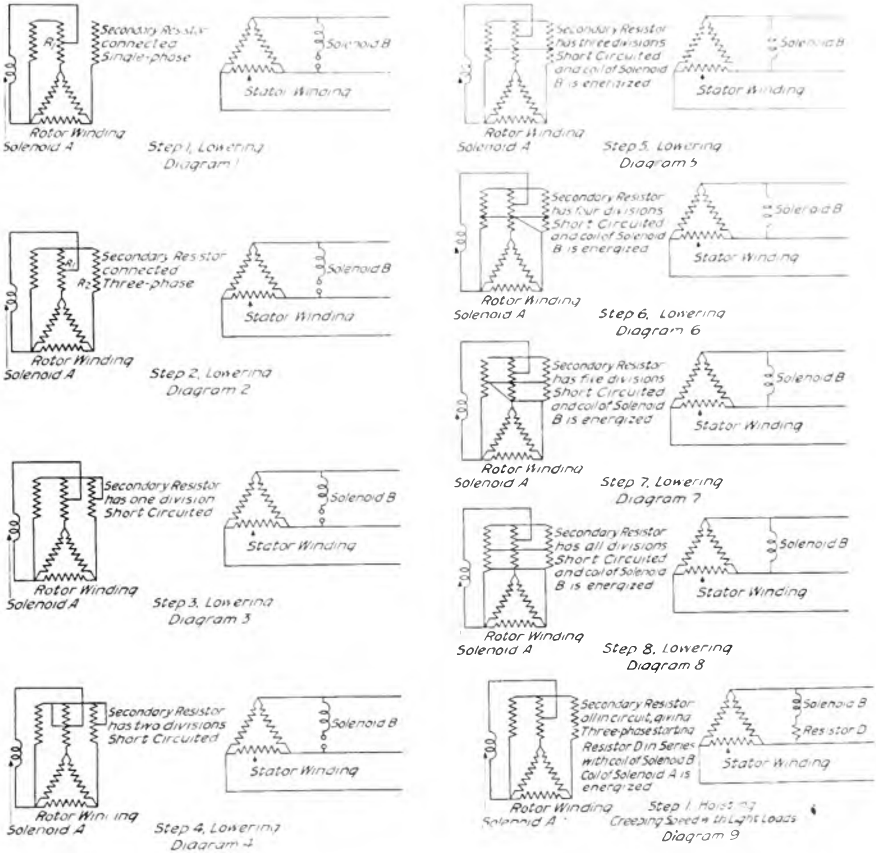
The solenoid load brake will give better results on creeping speeds when lowering loads than will the automatic mechanical load brake, principally because the solenoid load brake is a large open device whose adjustments are accessible and do not change due to wear. However, when the mechanical load brake and a solenoid load brake are in an equal degree of adjustment, the operating results are practically on a par. The solenoid load brake gives creeping speeds with practically the same certainty as does direct current with dynamic braking, but not quite so accurately under all conditions of voltage, temperature, wear, etc. It is possible to jog with a greater degree of accuracy on a crane using the solenoid load brake than on a crane using either of the other two types of braking. The reason for this is that when jogging is done with the solenoid load brake the solenoid does not pick up and set, thus requiring considerable time during which the brake shoes are released and the motor may revolve. The weight of the solenoid core is simply released, and the brake wheel slips slightly. There is no time wasted while a solenoid is picking up and dropping down. It has been found easy on actual test to jog the motor armature one twentieth of a revolution.

A solenoid load brake serves the double purpose of a lowering device and an ordinary solenoid brake, with the safety of stopping when power fails. On direct-current cranes which use dynamic braking in combination with a solenoid brake it is sometimes considered advisable on account of the size of the crane, value of the material, or danger connected with handling, to use not only a solenoid brake on the motor shaft, but also a solenoid brake on the jack shaft. This same practice, for the same reasons, would be advisable in the case of a solenoid load brake on an alternating-current crane; that is, a single torque standard solenoid brake might be added to the back shaft.

The value of retarding torque which a solenoid load brake should have should ordinarily not exceed 125 per cent of the rated torque of the motor. It is advisable to make the torque of the brake as small as possible so as to eliminate unnecessary shocks, jars, wear, and tear. It seems to be the usual guarantee on cranes that they will hoist 125 per cent of their rated load; and, if this corresponds to 125 per cent of the motor rated torque, a brake set for 125 per cent torque would have ample capacity. When 125 per cent torque is required for hoisting, not more than 50 or 75 per cent torque is required to hold back against the load. This is because the friction in the crane machinery hinders when a load is to be hoisted and helps to hold a load from lowering. Therefore, under the conditions above a test load requiring 125 per cent of the motor torque to hoist would be retarded from full speed in lowering in something like two or three seconds. A usual load or no load on the crane would require something less than one second for retarding from full speed. Therefore, we are safe in saying that 125 per cent brake torque stops a test load quickly enough, and a usual load not too quickly. Furthermore, the ordinary alternating-current crane motor will not start and hoist as much as 200 per cent of its full load rated torque. Now to lower a load which required the maximum starting torque of the motor would probably require less than 100 per cent torque. Therefore, in the worst case there would still be about 25 per cent torque margin for retarding a load which was as large as the motor could possibly hoist.

This 25 per cent is a rather small margin, but it has been found to be good practice in direct-current cranes, which use dynamic braking, to set the solenoid brake for a relatively low value of torque. When in an emergency an extremely heavy load, much beyond the rated capacity of the crane, is to be hoisted, a man is sent to the top of the crane to manipulate the brake by hand so as to make sure that it stops the load. This is considered to be better practice than to use a brake which has too much torque.

In those cases where an extra brake on the back shaft is used it would ordinarily be good practice to adjust the solenoid load brake for something like 100 per cent or less of the rated motor torque, and adjust the single torque brake on the back shaft so that it retards with a torque of something like 75 per cent of the rated motor torque. That is, the [illegible] shaft solenoid brake [illegible] shaft should be about [illegible] motor torque. The [illegible] brake would be some [illegible] value, depending on the [illegible] The back shaft brake should [illegible] adjusted so that in case [illegible] controller handle is thrown [illegible] off position, it will set smoothly [illegible] or one second after the solenoid load brake sets. This precaution eliminates [illegible] backlash, and wear and tear on the [illegible] pinion and first gear reduction.



Step 1, Lowering Diagram 1

Step 2, Lowering Diagram 2

Step 3, Lowering Diagram 3

Step 4, Lowering Diagram 4

Step 5, Lowering Diagram 5

Step 6, Lowering Diagram 6

Step 7, Lowering Diagram 7

Step 8, Lowering Diagram 8

Step 1, Hoisting Creeping Speed with Light Loads Diagram 9

Schematic Diagram of Connections on the Different Steps of the Controller

Fig. 1 shows that the adjustments for this brake are very accessible and very simple. Springs (*D*) and (*C*) can be readily adjusted to counterbalance the weight of the solenoid cores (*A*) and (*B*). The lever ratio through which pressure is applied to the shoes can be readily changed at the fulcrum (*L*). The electrical effect on solenoid (*A*), and consequently the magnetic pull on its core, can be adjusted to a considerable extent by shifting taps in the resistor which is connected in series with this coil as shown on the wiring, diagram 2.

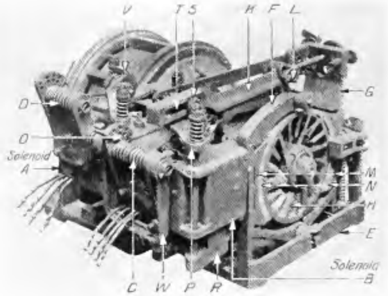


Fig. 1 Alternating-current Solenoid Load Brake Mounted on a 15 h.p., 900-r.p.m. Wound rotor Induction Motor

A detailed description of the mechanism and operation of one design of solenoid load brake will be given.

The solenoid load brake (Fig. 1) consists of a cast-iron frame (*E*) in which is mounted two hinged steel yokes (*F* and *G*), each of which has mounted therein a cast-iron shoe (*M*) with a molded asbestos compound face or lining (*N*). These shoes bear on a specially constructed ventilated wheel (*H*), which is mounted on the motor armature shaft. The wheel is so designed that air is drawn through the ventilating vanes regardless of the direction of rotation.

Two solenoids or electromagnets (*A* and *B*) are attached to one side of frame (*E*). These solenoids are connected to the brake shoes through a steel lever arm (*K*), the ratio of which, to give different braking torques, can be changed by putting a steel pin (*L*) in different holes in the lever arm.

The core (*R*) of solenoid (*B*) is connected to the lever (*K*) by means of a pin (*S*) through a slot (*T*); therefore when the core is down the brake shoes press against the brake wheel thus exerting torque, and when the core is up relieves the wheel so that it is free to turn. This solenoid is equipped with a balancing spring (*C*), one end of which is held by an adjusting pin (*O*) and the other end is under the yoke (*P*), tending to lift the core (*R*). This relieves some of the weight of the core (*R*) and produces different torque values on the brake wheel, depending on the position of pin (*O*).

The core of solenoid (*A*) rests on lever (*K*), but it is not fastened to it as is the core of solenoid (*B*); therefore the weight of the core only produces torque at the brake wheel but does not release the shoes as does the core of solenoid (*B*). Solenoid (*A*) is equipped with a balancing spring (*D*) which relieves some of the weight of the core, as explained. The core of solenoid (*A*) cannot be raised so that it will have a magnetic seal with its armature, because a stop (*W*) is provided so that the core can only be raised a certain distance. The reason that a magnetic seal is avoided is that the core must act quickly in a downward direction, and this condition would not obtain if the core sealed. This stop is so constructed that it is made inoperative when the core of solenoid (*B*) is raised, as it is necessary in this case that the core of solenoid

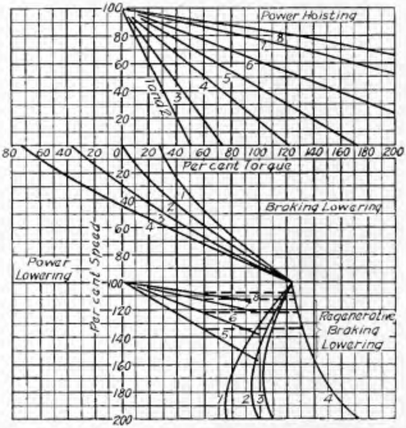


Fig. 2. Torque-speed Curves of a Wound rotor Induction Motor Combined with a Solenoid Load Brake

(Solenoid *A* on 60 per cent rotor voltage tap)

(A) should be raised to the sealed position as is solenoid (B).

The coils of each solenoid have four lead (1, 2, 3, 4) brought out, and the coils are so proportioned that they take care of low, normal, and high voltage.

The coil of solenoid (B) is connected through the controller to the primary side of the motor and the coil of solenoid (A) is connected directly across one phase of the motor secondary through the secondary resistor.

The operation of the brake is as follows:

On the first step on the hoisting side of the controller the coil of solenoid (B) is energized and immediately raises the core (R) which releases the brake wheel so that it is free to rotate. As soon as the core of this solenoid is raised solenoid (A) has no effect on the operation of the brake; therefore, in the hoisting direction the solenoid load brake functions the same as any ordinary single torque solenoid brake.

On the first step of the controller, on the lowering side, power is applied to the motor; and the coil of solenoid (A), being connected across one phase of the motor secondary, almost raises its core and thus relieves the lever (K) of part of the total weight. The coil of solenoid (B) is not energized on this step of the controller and therefore the brake exerts a torque proportional to the weight of the core (R). If the weight of the load on the hoist plus the torque produced by the motor is more than the torque exerted by the brake the motor armature starts to revolve. However, if the torque exerted by the brake is more than that produced [illegible] motor, the motor armature [illegible] stand still. As the motor progresses [illegible] revolve the secondary voltage [illegible] the core of solenoid (A) [illegible] lever arm (K). Therefore [illegible] is a maximum when the motor is running at maximum speed and a minimum when at standstill. The coils of solenoids (A) and (B) are connected the same on steps 2, 3, and 4 as on step 1, but the torque developed

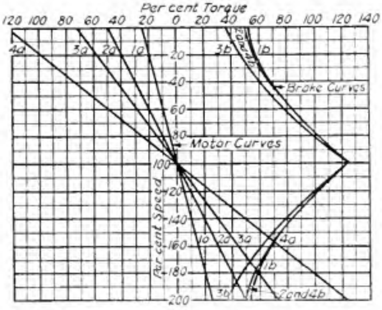


Fig. 3. Torque-speed Curves of a Wound-rotor Induction Motor and Solenoid Load Brake

(Solenoid A on 60 per cent rotor voltage tap)

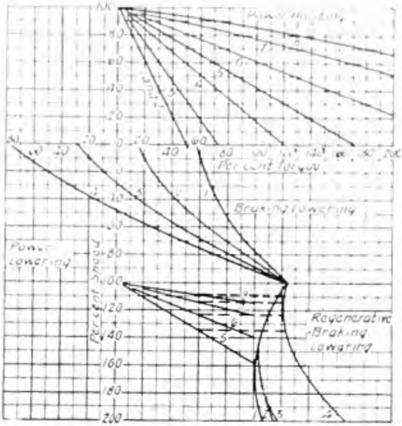


Fig. 4. Torque-speed Curves of a Wound-rotor Induction Motor Combined with a Solenoid Load Brake

Solenoid A on 50 per cent rotor voltage tap

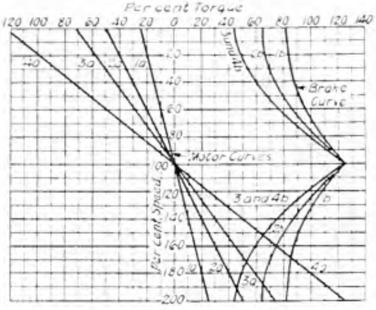


Fig. 5. Torque-speed Curves of a Wound-rotor Induction Motor and Solenoid Load Brake

Solenoid A on 50 per cent rotor voltage tap by the motor increases on the different steps. Also, the resistors R_1 and R_2 are manipulated on steps 2 and 3 to raise the standstill voltage on coil (*A*). Therefore, for the same load on the hoist the speed increases on the different steps. On step 5 solenoid (*B*) is energized, and on this and the remaining steps the solenoid load brake is the same in effect as a single torque solenoid brake. On steps 5, 6, 7, etc., the brake being entirely released, the motor runs above synchronous speed, the speed depending on the load on the hoist and the step of the controller. The fifth step gives the highest speed and the last step the slowest speed above synchronism with the same load on the hoist. A light load gives the slowest speed and a heavy load the highest speed.

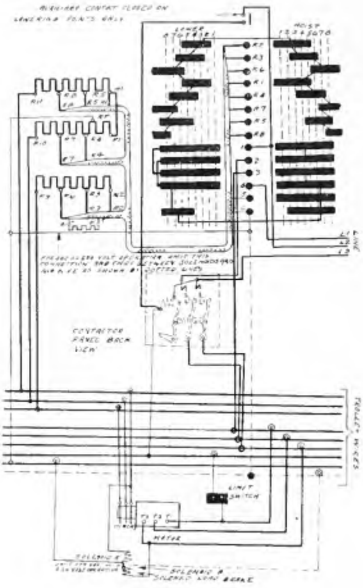


Fig. 6. Typical Wiring Diagram Showing Connections of Solenoid Load Brake, Limit Switch, and Contactor. Creeping speed on first hoisting step of the controller

Fig. 2 shows torque speed curves of an induction motor equipped with a solenoid load brake. Curves 1, 2, 3, and 4 in the lowering direction are the algebraic sum of the motor and solenoid load brake curves 1a and 1b, 2a and 2b, 3a and 3b, 4a and 4b, respectively shown in Fig. 3.

The solenoid load brake curve 1b shown in Fig. 3 is obtained with 60 per cent standstill rotor voltage across the coil of solenoid (*A*) on step 1 of the controller. This standstill voltage changes on steps 2, 3, and 4 as the rotor resistor values change, thus giving the different curves 2b, 3b, and 4b, as shown.

The results of changing the tap from solenoid (*A*) in the resistor from 60 to 50 per cent will be seen by referring to Fig. 4. Fig. 5 shows the motor and brake curves whose algebraic sums give the curves of Fig. 4.

If loads which are equivalent to about 60 per cent torque are to be lowered as a regular thing, it would be better to use the 50 per cent tap (Fig. 4) rather than 60 per cent tap (Fig. 2) as it will be seen that with 60 per cent lowering torque the speed on step 1 is about 10 per cent. It can readily be seen that the load can be lowered on step 8 at about 110 per cent speed, delivering power to the supply system, and just before landing the load the speed can be changed to about 10 per cent by turning back to step one. Considering ordinary crane hook speeds 10 per cent would be very low and the load can be very easily landed. However, if 60 per cent torque is lowered with solenoid

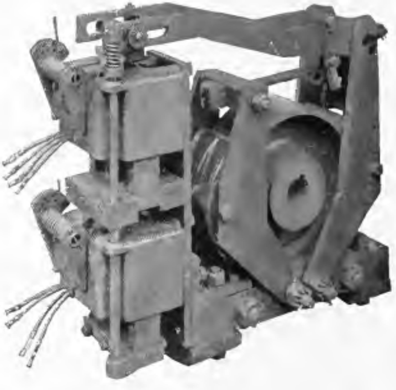


Fig. 7. Solenoid Load Brake with one Solenoid above the other. This brake functions the same as the solenoid load brake in Fig. 1

(A) connected to the 60 per cent voltage tap step 1 will give about 50 per cent speed as per Fig. 2.

Torque speed curves are shown in Fig. 2, and it will be noted that when running on step 5 of the controller in the lowering direction, with a load on the hook corresponding to 60 per cent torque, the speed will be about 135 per cent of the hoisting speed. If the controller is turned to step 1 the torque peak will be about 132 per cent, decreasing to 125 per cent at 100 per cent speed, and then gradually falling off to 60 per cent torque at 72 per cent speed. It can readily be seen that step 5 can be changed to give higher lowering speed without getting excessive peaks when turning back from step 5 to step 4.

If a resistor is inserted in the circuit of the coil of solenoid (*B*) on step 1, hoisting, diagram 9, a creeping speed can be obtained with a very light load on the hoist. This is of advantage on machine shop and foundry cranes, where it is necessary to have a definite slow hoisting speed for light loads.

Diagram 9 shows the schematic connections of step 1, Fig. 6, and it will be noted that a resistor (*D*) is inserted in series with the coil of solenoid (*B*). [illegible] lowers the voltage [illegible] but if [illegible] energized by the unbalanced [illegible] of the motor, the brake [illegible] released. A vibrating action of [illegible] solenoid (*B*) actually releases the brake somewhat and with the motor [illegible] approximately 50 per cent torque, a light load [illegible] hoisted at about 25 per cent of the full load hoisting speed.

On the second step of the controller, resistance (*D*) is short-circuited, thus applying full voltage to the coil of solenoid (*B*) which entirely releases the brake.

If the resistor in the rotor circuit is connected so that 25 per cent torque is obtained on the first hoisting step of the controller, a small variation in torque gives a large variation in speed on account of the steepness of the torque speed curve. When resistance (*D*) is inserted in series with solenoid (*B*) and the rotor resistor is arranged to give 50 per cent torque on the first hoisting step of the controller, a small variation in torque gives a small variation in speed because the torque speed curve thus obtained is flatter than the 25 per cent torque curve mentioned above.

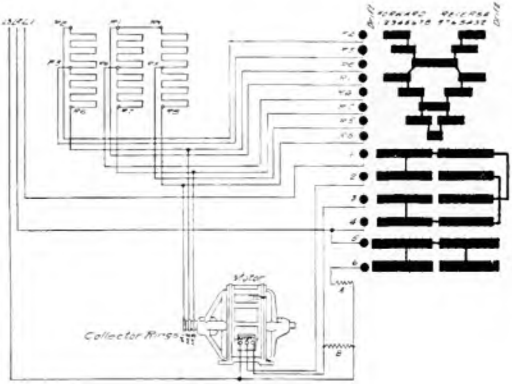
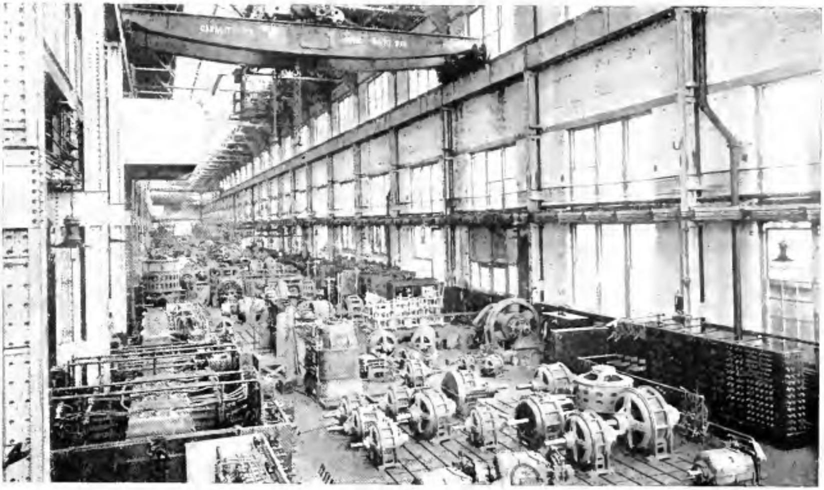
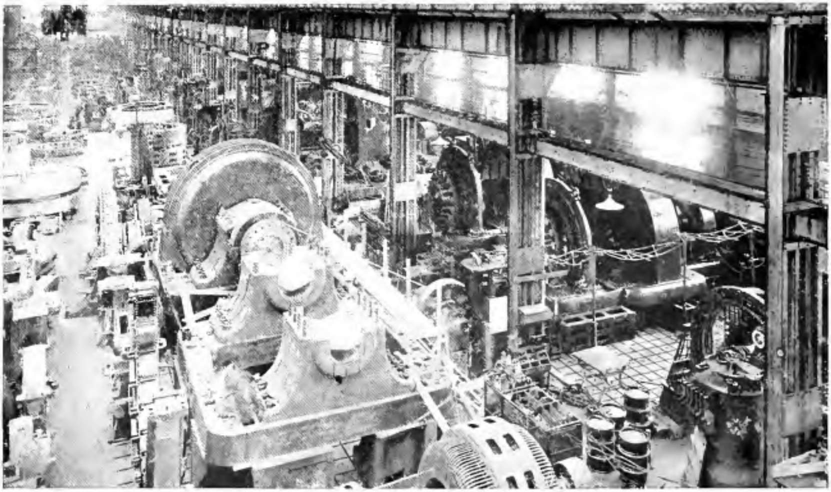


Fig. 8. Typical Wiring Diagram Showing Connections of Multiple Magnet Solenoid Brake



Induction Motor Building, Schenectady Works



Large Motor-generator Sets in Test at Schenectady Works

VIEWS IN GENERAL ELECTRIC COMPANY FACTORIES

Salvaging Miscellaneous Wastes

By W. R. Conover

Economist, General Electric Company

The subject of salvaging industrial wastes [illegible] being [illegible] careful [illegible] manufacturing companies, and its field of operation is [illegible] growing. We [illegible] our industries in the near future, all classes of manufa[illegible] methods and conserve their by-products, as the increa[illegible] of production [illegible] always be done by advancing the selling price, due to [illegible] of competition. [illegible] points out, it is our duty to conserve everything.—Editor

There are many by-products relatively as important as the chips and turnings, castings, and heavier metals which we need to conserve. The manufacturer's efforts to salvage industrial wastes must extend over a much wider field than is included under the classification of metal by-products alone if we are to secure the desired results and accomplish a nation-wide saving of everything of value in military production or in private commercial undertaking. If actual fighting has ceased and peace is reasonably assured, we are just entering upon the period of reconstruction which will of necessity be of long duration. In the work of rehabilitation of devastated and war-torn Europe we must take a leading and active part. Our duty, therefore, is to conserve everything, not only to lighten the burden of reconstruction work and make easier the task of our national government, but also to enable the government and nation to set before the world and especially before the impoverished countries of Europe, whose treasuries have been depleted and whose credit has been impaired by the prosecution of the war, that broad and high example of economy and right living which is now manifestly our privilege and obligation to establish and maintain.

There are numerous by-products in addition to those we have been discussing* which must receive our earnest attention and critical consideration. Failure to do our utmost along this line places the greater economic burden on the shoulders of someone else where it does not properly belong. The products of leather and rubber industries, of woolen and cotton mills, of chemical industries, of fabrics of every kind, offer a most fertile field for the salvaging of the smaller classes of wastes resulting from the manufacture of these varied classes of materials.

In the Schenectady plant of the General Electric Company many miscellaneous by-products reach the main scrap building which add greatly to the amount [illegible] salvaged during the year. Rubber, le[illegible] fiber, rope, strings, muslin rags, cloth trimmings, burlap sacks and wrappings, worn out belting, asbestos sheeting, armature and field insulation papers, and small [illegible] of productive materials in various forms and stages of shop processes, which have been condemned by the inspection force as unfit for further productive use, are sent to the main scrap building to be sorted and prepared for shipment. Scrap sheet steel and fiber sheets of suitable thickness for making washers are saved and sent back to the metal punching departments for the production of various sizes of washers. Insulated wire ends, clippings, and short lengths of cable and conductor remaining over from production or from shop wiring jobs are delivered to the scrap building where the insulation is removed by burning, leaving the clean copper wire in shape for shipment to the open market. The bundling machine, which is designed to wind bundles of suitable size for charging standard crucibles, takes care of a considerable percentage of loose copper wire reaching the scrap building. The cotton fabric scrap and scrap from other materials used in the braiding of cables and manufacture of insulated wire are all subjected to the process of reclamation. Some of this left-over fabric is used in the wire department in place of cotton waste for cleaning machinery, etc.

In the mica insulation department there is a constant accumulation of waste from the production of mica insulations, on which an average of nearly three hundred hands are always engaged. This waste product is treated in furnaces for the purpose of burning out varnish, paste, etc., which renders it available for further use in the production of insulated sheets which are cut into various forms of pasted mica as required.

Cables, Slings, and Belting

Rope slings which have been cut in the process of lifting or are worn by use are

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* "Salvaging Industrial Wastes," by W. R. Conover, General Electric Review, Jan., p. 88.

inspected by the chief rigger and where practicable are made into shorter lengths. The balance of these slings is sent to the scrap building and sold with other waste fabrics. There is also maintained a regular inspection of steel crane and elevator cables. Whenever these cables become sufficiently worn or the strands broken in such a manner as to reduce the factor of safety, they are replaced with new cables. The old cables are utilized for steel slings, the defective portions having first been removed. Steel slings are used to a large extent in the machine shops of the Schenectady plant, and a large percentage are made from cables removed from elevators and cranes. The highest degree of safety is maintained by this system on all lifts either by elevators or cranes, and the second-hand steel slings always insure a large margin of safety in the handling of heavy castings or other material. The millwright department, which takes care of all belting equipment except the minor repairs and lacings made by the local belt lacers in the shops, inspects all worn belts, utilizing all good portions for making shorter length belts and also for repairing, and saving the balance which is disposed of through the scrap department.

Paper By-products from the Shops and Offices

The waste cuttings and trimmings of armature and field coil insulations, cable paper, press board papers, and other papers used in production are accumulated in sacks in the various shops and sent to the main scrap building for storing and shipping. These papers are kept carefully separated in the manufacturing departments, thus avoiding the labor of sorting at the scrap building, and insuring the receipt of the highest market prices for the various grades. Wrapping papers received on incoming materials are accumulated and sent to the central stores building to be used in wrapping small packages of materials delivered out to the shops. In the end, these papers reach the salvage plant and are baled and sold to the dealers. Magazines and periodicals are put into separate bundles for which a proper rate for this classification is obtained. Blue prints and printed office forms which have served their original purpose are cut and glued into pads and the backs of these sheets are used in the various shop offices and on the shop floors for scratch-pad purposes in systematic effort to reduce as far as practicable the expense of clerical routine. As in the case of wrapping papers, they are eventually sold as scrap product.

Waste papers are collected from the general offices, engineering offices, production, accounting, and shop offices in sacks, and in this manner sent to the salvage plant on the refuse cars. These papers are run through a slitting machine and then baled for shipment to the mills. In the process of baling paper and excelsior, board trimmings and scrap wire received at the building are utilized exclusively. Asbestos paper and sheeting, used as insulation material in certain classes of manufactured product, are saved by the shops and delivered to the scrap building for shipment. Some of the asbestos used in laboratory processes has been sent to glove manufacturers and made into gloves, effecting a reduction of about 75 per cent in the cost of new gloves.

During the past two years more than 300 tons of the waste papers from offices have been accumulated annually and put through the slitting machine and baled for the market. The total paper by-products shipped annually from the Schenectady Works amounts to more than 550 tons. This will be increased considerably during the present year.

Lumber By-products, Boxes, Barrels, etc.

Reclaiming waste lumber offers a good field in most factories to effect a large saving in material with a comparatively low labor cost. Lumber left over from the construction of new buildings, also from alterations and repairs, is carefully sorted, the nails, bolts, or rods removed and returned to stock for further use in making repairs, concrete forms, temporary stagings, platforms, etc. A quantity of lumber can be reclaimed from the larger housings and cases in which incoming machinery and materials are received, and most of the lumber in the longer cases in which metal rods and sheet metal strips are freighted is adaptable to these temporary purposes. When these latter boxes are of sufficient width and depth, they can be converted into shop tote boxes to good advantage by sawing them into sections approximately 18 in. long, nailing in ends, and banding with strap iron where necessary. Such boxes will last as long and are as durable as those made of new material at two or three times the cost. All of the medium and smaller sizes of incoming boxes are suitable for transferring materials about the shops or for holding materials in storage. A nail puller should be used in removing the covers in preference to a pinch bar, as the lumber in these covers is useful in repairing broken boxes and also in making ends for the sections into which long boxes are cut. As rapidly as boxes become worn or broken in transit about the factory, they are sent to the salvage department and put in a condition of good repair. By this means a constant supply of second-hand boxes is kept passing back into the manufacturing departments and store rooms. Many of these boxes are of large size and are used for shipping material to the other plants of the Company. Between 500 and 600 boxes per week are being repaired in the salvage building at the present time, or a total of nearly 30,000 per year. The value may be conservatively estimated to exceed $12,000 annually.

Wood and steel oil barrels, also cans in which oils and chemicals have been received are all valuable for further use. The barrels should be steam cleaned and used for the shipment of oils and chemicals outside, or for their delivery to the various shop departments. The smaller cans are always useful for the painting gangs about the factory. Steel barrels which have become leaky make good containers for chips and turnings and the smaller scrap metals. Handles should be riveted to the sides for handling with the shop cranes. Strawboard or pasteboard cartons in which incoming materials have been received are suitable for delivering small or light materials from the central store house to the shops.

Miscellaneous Shop Supplies

The various classes of shop supplies are usually sources of greater or lesser degree of waste. Emery cloth and emery paper, cotton waste, muslin and cheese cloth, brooms, brushes, lamp globes, gloves, twine, etc., are some of the expense supplies used in nearly every shop. The first three items are frequently subject to the greatest degree of extravagance in use. The consumption of these materials, however, is within the limit of control if proper regulation of their use is established. Emery cloth and paper, partially worn or filled with metallic or other substances, may be readily cleaned with an ordinary wire bench brush and its life thus prolonged. The corners of sheets remaining from the cutting of emery wheel disks can be cut into rectangular shapes and used on some classes of work. The workman may also be taught to conserve his supply and use it to the best advantage by requiring him, when obtaining his [illegible] order for a fresh supply [illegible] present lot has been utilized [illegible] value consistent with the [illegible]

Cotton waste is an item on [illegible] restriction is usually placed and [illegible] has received some attention and [illegible] to methods of extracting oil, cleaning and reclaiming. It is better practice to [illegible] a proper system of distribution in the [illegible] than to depend on the process of [illegible] as a means of reducing cost and [illegible] supply. Oil may be extracted from [illegible] in an ordinary cylindrical extractor, but the oil is often of inferior quality as it is generally a mixture of bearing oil, cutting oil, and sometimes of soluble solutions where the waste is gathered from several departments and requires careful filtering to free it from metal smut and other foreign elements before it is fit for further use. Waste may be steam cleaned to advantage so that it can be used for purposes other than wiping the workman's hands where it is liable to cause irritation because of the fine particles of metal which usually cling to the fibers. A controlling system of supply and distribution is the best answer to the problem of reducing consumption and preventing undue loss. The foreman's order on the stock department for his regular weekly supply should be based on the number of productive employees, allowing a given average number of ounces per employee (according to the class of product manufactured) as a controlling factor in determining the total supply in pounds required. The usual fluctuations in productive employees obviously fluctuates the total weekly supply drawn from stock. The internal distribution to the men must necessarily be governed by the kind of work each employee is doing. A bench hand engaged in assembly or other processes practically free from dirt or oil requires a very small allowance, while the operator on large machine tools or automatics must have at least a quarter pound or more per machine, according to conditions, for his regular weekly supply. In like manner, the controlling multiple or factor in some departments may be as low as one half to one ounce per employee, and in others reach as high as four or six ounces, but it is safe to state the case is an exception and not the rule where the class of product manufactured would make necessary an average distribution to the employee of one half pound per week. Waste required for special purposes, su as cleaning production materials, special cleaning up of machine tools which are taken down for rebuilding and repairs, straining varnishes or compounds, and similar purposes, should be kept separate from the workman's regular weekly supply and the quantity governed by the conditions and processes for which it is required.

Such supplies as brooms, brushes, twines, lamp globes, gloves, and other protective clothing, etc., and materials such as muslin, felt, and various cotton fabrics are all susceptible to regulation and restriction which will prevent undue consumption and waste. In general, the workman's order for a fresh supply should be approved by the foreman before being filled by the stock keeper, and the worn or discarded items should be returned to the store room with the order. This accomplishes a twofold purpose. It places a check on the employee to insure that his supplies are utilized to the fullest extent and advantage consistent with the nature of his tasks, and it insures the saving and accumulation of the materials for further use wherever practicable or for scrap.

Brooms which have become too much worn for effective service in cleaning the shop floors are suitable for certain kinds of yard cleaning or other rough work. Brushes which have served their purpose on painting specific classes of productive work are still of value for many rougher processes, outside painting, etc. Lamps having leads attached for portable use should always be protected with wire guards, and the stubs of broken lamps saved for the brass scrap. Gloves with ripped seams should be cleaned and mended, and worn-out gloves can be sold as leather waste. The consumption of gloves and other protective clothing should be controlled by instructions restricting their use to processes which render their being provided essential to the health and safety of the employee. Felt trimmings are useful as padding on trucks, trays, or containers employed in handling fragile and polished materials, and are frequently adaptable to small cleaning and polishing operations. Muslin fabrics and cloth remnants of suitable size can always be utilized for cleaning and dusting purposes and usually can be subjected to repeated washings before being discarded and sold as scrap product.

Lubricating and Cutting Oils

Lubricating and cutting oils and compounds constitute a relatively large proportion of the expenditure for shop supplies in most factories. The oil house should be equipped with steel tanks in which to keep the stock supplies, as there is always more or less loss from seepage where oils are kept for any considerable time in wood barrels. In order to control consumption, it is essential to provide the stockkeeper and foreman of departments with a printed or written schedule of instructions designating the kinds of oils which are to be delivered to the shops for the various classes of productive processes and also for the lubrication of machine bearings, slides, journals, etc. It is sometimes desirable to schedule a definite amount to be supplied for the lubrication of the different types of machine tools in order to prevent the operator from being wasteful in practice. When this is done, the supply should be determined by careful tests and not left to the judgment of the overseer or operator.

Where a number of machines are grouped and operated continuously on the same kind of cutting oil, the installation of an overhead tank and system of piping leading to each tool is an essential factor in economic operation. Much depends on a proper flow and feed of oil to the tool and the surface cut in obtaining the best results. The workman needs to be fully instructed as to the importance of regulating the supply in such manner as to reduce friction to a minimum, not simply as a means of securing speed and precision, but as a necessary part of his shop practice to save and conserve and thereby reduce manufacturing costs.

All machines should be provided with drip pans and in many cases, such as automatics, with aprons or shields to prevent the spatter of oil upon the floors.

Filtering devices are always a part of the equipment of the up-to-date shop to enable proper cleansing and renewing the lubricating and cutting value of oils deteriorated in operation.

Much can be done toward reducing the expenditures for lubrication by the substitution of properly combined mineral oils and oil bases for straight lard oil, and by systematic and careful designation of some of the cheaper oils or soluble compounds for light work on brass and steel.

Fuel Gas and Fuel Oil

In the bigger mechanical industries the cost of fuel gas and fuel oil represents a large expenditure because of the usually very large consumption. They are generally subject to much waste and loss due to improper equipment and lack of proper supervision and attention. It is essential in the first place that all valves and openings on furnaces and supply pipes, on soldering fixtures and other heating devices, be of the proper size and that automatic controlling attachments be installed and used wherever possible. Only by this means can economic operation be maintained.

Bench gas fixtures used for heating and soldering purposes are always a source of waste. Unless provided with automatic control, the flame is left burning full when the workman is away from his work and often for long intervals when not required for productive processes. Where not practical to equip with automatic control, the workman should be taught to cut the flame to pilot size when not in actual use. Usually a careful investigation will reveal that many, if not most, of the openings of bench fixtures, and sometimes the feed valves of furnaces and ovens, can be reduced in size and save a considerable percentage of the waste.

Compressed air is often a source of waste to which both foreman and workman give little attention. Few shop men stop to consider the cost of the power used in the production of air for pneumatic tools. Leaky valves and pipes need constant attention. The workman should be instructed always to close the valve connecting the pipe supplying his tool with the main line, when air is not required, and to take all other means possible to conserve the supply.

Too much emphasis cannot be laid on the importance of proper distribution and use of expensive shop supplies in order to avoid waste. The argument is sometimes offered against systems of regulation and distribution involving the return of used materials, that they require too much of the workman's time, and interfere with the more essential production routine. In general it would be difficult to demonstrate the correctness of this assumption. Proper systems of control not only enable the foreman to know that all supplies charged to his department are utilized to the best advantage, but they teach the workman the necessity and value of maintaining uniform, consistent habits of thrift and precision in all his work.

Power, Heat, and Light

In giving consideration to the salvaging of factory wastes we must not overlook the fact that the power source offers opportunity for a large degree of economy or waste. In order to secure the highest efficiency and to prevent waste and loss in the production of power, and also of heat and light, it is essential not only to install modern types of generators and auxiliaries and modern types of boilers and boiler house equipment, but also to establish scientific methods of operation. High engineering skill is required in the layout of the station, in order to provide the generating capacity needed to meet all the shop conditions under varying temperatures, and more or less constant fluctuation of load.

Men of extensive experience are needed not only for the work of supervision but for all the various functions of power house labor as well. Inspection and care of generators and auxiliaries, switchboards, instruments, oiling systems, etc., must be of the highest order. Constant attention must be given to flues and grates, regulation of drafts, maintenance of clean, bright fires, care of feed water, etc., in order that combustion may be complete and chimney and other losses avoided as far as possible. Careful consideration should be given to the purchase of fuels with reference to the percentage of fixed carbon, volatile matter, sulphur, ash, and moisture, selecting those fuels which develop the highest number of heat units without too high a percentage of sulphur or ash.

All the waste materials of the power house at the Schenectady plant are systematically reclaimed. Cylinder and bearing oils which have become dirty from service are filtered and their life increased by the addition of new oil. Cotton waste and cloths are washed and used repeatedly until their value is exhausted. Repair parts, piping, valves, old belting, and other supplies are either retained for some further purpose or sent to scrap. Nothing of value is allowed to escape the process of reclamation. Even the cinders and ashes daily removed from the boilers serve a valuable purpose for the underlying base of plant roadways and trackage, and for filling low ground areas.

The shop foreman has an important duty to perform in preventing waste of power, heat, and light. He should give the same personal attention to regulation and control of these elements of shop supply that he would devote to other routine economies. Field switches should always be opened and current cut off when shop motors are not in use; proper ventilation should be maintained and valves closed in order to save steam when the temperature exceeds a healthy normal; and lights should be turned off during working hours when the radiation and diffusion of natural light is sufficient. In these and other ways the shop foreman can be of vast assistance in preventing power house waste and loss.

Destructor and Salvage Plant

The destructor and salvage building has a floor area of 13,500 square feet. There are two 300-h.p. boilers in the main section which are fed by refuse and waste products collected from the shops and yards which are not scheduled to be delivered to the main scrap building or burning dump. Two trains of several cars each are in constant operation, hauling these materials from the shop sidings and platforms to the building.

Refuse lumber from construction jobs, repairs, and alterations, incoming boxes from which raw materials have been removed, broken shop tote boxes, and other miscellaneous waste materials reach the destructor plant by the dump trains. Waste products of the carpenter shop, board ends shavings, sawdust, etc., are delivered to the building by an overhead conveyor. All materials of value are saved and put in stock for further use or sent into the adjoining salvage building to be repaired and returned to the shops, as is the case with broken boxes. Much of the lumber reclaimed is stored in piles where it is accessible to the grounds and buildings organization. The excelsior removed from incoming cases is baled and forwarded to the shipping departments. A supply of sawdust is delivered regularly to the porcelain factory for use in packing porcelain insulators and other parts for shipment.

The steam production from the two boilers is delivered to the shop mains and amounts to over 50,000,000 lbs. annually.

The salvage department, containing 3800 sq. ft. of floor space, is devoted to important reclamation work. The equipment consists of a paper slitting machine, baling press, hand and rip saws, cinder mill, washer, etc. Here all the waste papers collected from the offices are cut and baled. Incoming boxes and broken tote boxes are repaired and returned to the shops. The long lengths of boxes in which copper, brass, and other metals are received are sawed into sections of suitable length, supplied with ends, and sent to the central stock building and shops to be used in delivering and handling materials in the various departments about the plant. When these boxes are of too small dimension for the above purposes they are carefully taken apart and the material used for concrete forms, also for box repairs, cutting into ends, side pieces, etc. Second-hand material is used exclusively in this repair work, and the production, as previously stated, averages between 500 and 600 boxes per week.

The cinders from the destructor plant furnaces are put through the operations of reduction and cleaning in the cinder mill, and forwarded to the main scrap building for the extraction of metals.

Cotton waste and cotton fabrics of various kinds are collected and washed and returned to the manufacturing departments and offices, and through this means are used repeatedly for cleaning, dusting, and polishing.

Inspecting Factory Grounds

It is essential to establish a regular system of inspection of all factory yard areas and of contiguous grounds about shops, and to collect all materials which have been inadvertently left by workmen on the completion of jobs. One or more men should be regularly assigned to this work. At the points of filling of low ground areas (usually styled the factory dump), men are assigned to the task of raking over the refuse discharged by the dump trains before it is thrown into the fill. In this manner any pieces of metal, rubber, rope, or other scrap of value which have got into the refuse by accident, are reclaimed and returned to the by-products building.

Improved Methods of Handling By-products

The industrial world is now emerging from a period of intensive war production and entering upon a period of reconstruction and rehabilitation of the countries which have suffered loss and retardation through the progress and devastation of the war. A general speeding up of industrial processes will doubtless be necessary to keep pace with the demand for raw materials and finished fabrics which will be needed to place the world again on a stable and prosperous basis of economic existence. This will make new and more scientific methods of handling materials not only desirable but essential. Involved in these changes will be the important question of improved methods of handling factory by-products. Transveyors under floors, receiving chips through chutes direct from parallel lines of machine tools, oil extractors, metal separators, cutting, bundling, and baling apparatus, and conveying equipment of various kinds, will be required for collecting, preparing, and loading for shipment the by-products of the big industry of the future.

Urgent Call for Greater Conservation

No appeal to the manufacturer to save and utilize by-products can be made too forcible or too strong. What we need throughout the whole extent of our American Republic today is to learn individually and collectively as a nation the vital principles of economy and conservation. We need as a people to learn to save everything—of whatever intrinsic value—not simply during the present moment of great world-wide demand, not simply during the coming period of reconstruction work, but for all time to come there is insistent need to [illegible] the principles of thrift and economy [illegible] industrial undertaking. [illegible] extravagance and wasteful [illegible] to be decried, and [illegible] of labor and credit upon the saving of the so-called unimportant things—the smaller by-product of manufacturing.

It should be the purpose of the management of industries, both large and small in all parts of the country, to conserve everything possessed of inherent value. The question of profit in the process of reclamation should not always be the chief or deciding factor. It should be our aim to render all the assistance possible both to the national government and to the mills which manufacture raw materials or finished fabrics by conserving everything that may be of use in production, and by consistently following out this principle we will be of practical service to the public at large.

Single-collar vs. Multi-collar Thrust Bearings for Propeller Shafts

By H. G. Reist

Alternating-current Engineering Department, General Electric Company

In view of the large amount of shipbuilding proposed for the near future the following article is very timely. As the war is practically over, and we are about to enter a period of commercial reconstruction, probably of long duration, it will be necessary to conserve our resources in every possible way if we are to compete in the rehabilitation of Europe. From the data available the author assumes that the substituting of single- for multi-collar thrust bearings on the average merchant ship or transport would result in a saving of about one half of one per cent of the total power, coal, and size of boilers. The conservation of fuel alone, therefore, would be material, not to mention the saving in cargo space and first cost.—Editor.

The thrust from the propeller shaft of a ship is transmitted to the vessel through a thrust bearing. There are, in general, two types of thrust bearings in use; viz., the multi-collar horseshoe bearing and the single-collar thrust bearing. The former is usually known as a horseshoe bearing on account of the babbitted bearing surfaces having that general shape so that they may be readily removed and replaced. This bearing has six or more collars on the shaft, and babbitted plates or horseshoe bearing surfaces are fitted to each collar. This type has been in use for a long time and is found on the majority of ships today. It has several inherent disadvantages, but as formerly no equally satisfactory design was available this type was adopted by marine engineers as the standard. The successful development of the single-collar thrust bearing for supporting great weights in connection with large vertical shaft generators in hydroelectric power stations has led to the consideration of this type of thrust bearing for marine propeller shafts. Propeller thrust bearings start without load, which is a very favorable feature as compared with the hydroelectric thrust bearing which after standing idle must start at approximately normal load. Several designs of single-collar bearings have been tried on ships, and the use of this type is rapidly increasing.

It has been determined that the thickness of a film of oil in a bearing having a speed of 200 ft. per minute and a load of 80 lbs. per square inch is of the order of 0.0002 in. If the deviations from a true surface approximate the thickness of the oil film, there is the probability that no film will exist at some places. Also, the adjustment of the position

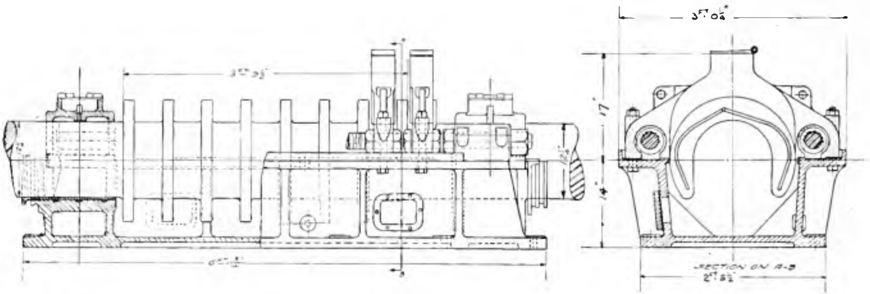

Fig. 1. Horseshoe Thrust Bearing for Supporting 30,000-lb. Thrust.

of the "horseshoe" must be correct within this limit and must not vary appreciably with changes in propeller thrust or temperatures of the parts. Otherwise, the metals will touch each other in some spots and will be so greatly separated in others that little load will be carried at these latter places. In actual practice, there are inaccuracies in fitting and alignment which result in a probable variation of pressures from zero to many times the average pressure on the total bearing area. It is frequently necessary to adjust the position of the "horseshoes" for variations in the speed of the vessel, so that even though perfect alignment was once obtained it can not be maintained continuously.

The difficulties of fitting and of maintaining a proper relation between the runners and the babbitted seats are inherent in the designs of rigid multi-collar bearings, and are largely avoided by the substitution of a single-collar thrust with a self-aligning bearing surface. With bearings designed in accordance with the single-collar principle, it has been found that the average pressure per square inch can be greatly increased and the size and weight of the bearings, and the losses, much reduced.

Losses

With the imperfect fitting and adjustment of the multi-collar bearing it is impossible to maintain an oil film between all of the bearing surfaces, and the losses are correspondingly great. This imperfect lubrication is responsible for the large coefficient of friction of the bearings, which Unwin states has a value of 0.035 according to Tower's experiments. As mentioned later, W. W. Smith derives a

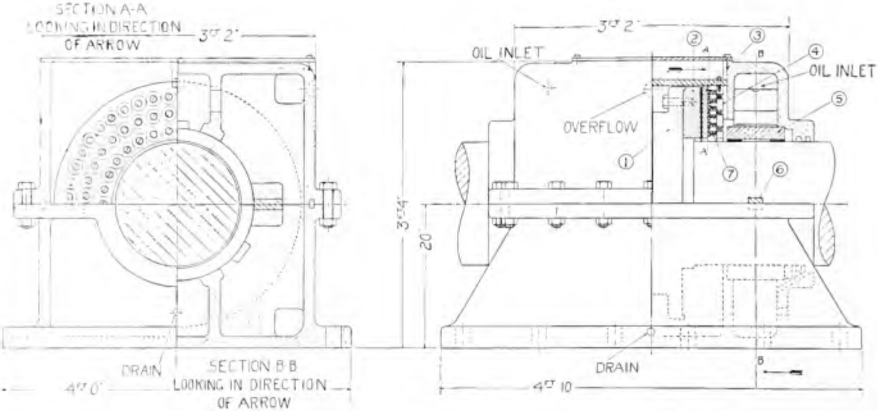

Fig. 2. General Electric Spring Thrust Bearing for 60,000-lb. Thrust. Located astern the engine on propeller shaft

value of 0.02 from Tower's experiment for bearings in the best condition. In Table I the latter value has been used, but it should be noted that generally the coefficient will be higher. Michell concurs in this opinion, claiming a ratio of 20:1 in the losses of multi-collar and single-collar bearings.

Referring to Table I, the left-hand column relates to an eight-collar bearing which assuming a friction coefficient of 0.02, gives a loss of 11.5 horse power. The coefficient of friction varies inversely with the unit pressure; and since the single-collar thrust bearing allows of high unit pressures, the logical procedure is to make the bearing surface as small as is consistent with safe operation. The pressure selected in this case is about that generally used, being 300 lbs. per square inch. The loss is but 1.0 horse power.

It is difficult to determine the friction loss in the multi-collar horseshoe bearings, under ordinary conditions of operation, so that very little information is available. In an essay on "Design of an Ideal Thrust Block," by C. P. Tanner, in the *Mechanical Engineer* of July 14, 1916, data are given regarding the losses in multi-collar marine thrust bearings.

TABLE I

COMPARISON OF MULTI-COLLAR AND SINGLE-COLLAR THRUST BEARINGS FOR A 12-KNOT SINGLE-SCREW SHIP OF 3000 HORSE POWER

Type of [illegible]	[illegible]	[illegible]
Revolutions per minute	90	90
Outside diameter of collar, in.	30	30
Inside diameter of collar, in.	12.5	12.5
Number of collars	8	1
Net area of bearing surface, sq. in.	1000	100
Pressure, lb. per sq. in.	50	300
Mean velocity of rubbing surface, ft. per min.	580	500
Coefficient of friction	0.02	0.0015
Loss, horse power	11.5	1.0

The losses are expressed in percentages of the effective horse power of the engines on different classes of ships and are as follows:

	Per Cent
Mercantile marine	0.4
Express steamers and large naval boats	0.5
High revolution and small naval boats	0.6
High revolution turbines	1.0 to 1.5

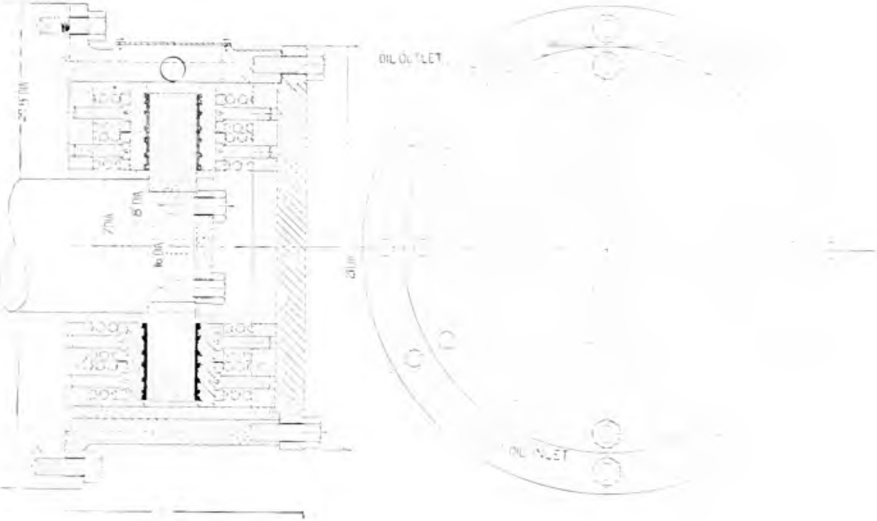

Fig. 3. General Electric Spring Thrust Bearing for 30,000-lb. Thrust. Located on end of propeller shaft

These figures agree with those given by W. W. Smith, Lieutenant, U. S. Navy, in an article in the *Journal of American Society of Naval Engineers*, vol. 24 (1912), in which the author compares the ordinary horseshoe thrust block and a single-collar thrust bearing. After describing various experimental tests on single-collar bearings, the writer says:

"No direct observations as to the frictional loss in an ordinary thrust block have been made; but, from experimental data, such as Tower's well-known tests, it appears probable that the coefficient of friction is not less than 0.02 when the bearing is in the best condition, and much higher than this when in bad condition. Because of the difficulty of fitting a thrust bearing properly, as pointed out below, it is believed that in service the coefficient is considerably greater.

"In a 30,000-h.p. battleship, the horse power of the main engines required to overcome the frictional resistance in an ordinary thrust bearing would be 146 for one shaft and 292 for both, the coefficient of friction being 0.02. Thus, 292 horse power, with the corresponding expenditure of fuel, is being constantly developed to produce useless work."

On single-collar thrust bearings the coefficient is much less and, according to a number of investigations, varies from 0.0015 to 0.003. In discussing this type of bearing Lieutenant Smith writes:

"A conservative value of the coefficient for a single-collar marine thrust bearing would be 0.002, and, for purposes of comparison, this value is assumed. Thus, in the same vessel the frictional horse power would be 14.6 for one shaft and 29.2 for both. This would be a saving of 262.8 horse power, or 90 per cent. In smaller bearings the frictional loss is actually less but proportionally the same; and hence it is of equal importance.

"In addition to the above, it is difficult to construct or to adjust an ordinary thrust bearing so that the load will be divided equally among the collars. In this respect, an old bearing is usually better than a new one, because it has ground off the high places. These characteristics make it unsafe to carry a high unit pressure on ordinary thrust bearings, and in safe practice it is usually limited to 40 to 60 lbs. per square inch. Because of the difficulty of fitting these bearings properly, their action is erratic, and it is by no means a certainty that they will run without heating. The use of cooling water permits considerable heating without danger, and, so to speak, it covers a multitude of sins. However, even with water cooling, it is impossible to predict with certainty the action of the bearing and to provide a definite factor of safety." *

The frictional loss of 292 horse power is approximately 1.0 per cent of the total 30,000 horse power of the given engines, and this percentage agrees very closely with that given by Mr. Tanner. The frictional horse power of 29.2 for the single-collar thrust bearing is one tenth of that for the horseshoe bearing, or 0.1 per cent of the total horse power of the ship.

With the above data in mind, it is proper to assume that on the average merchant ship or transport a saving of about one half of one per cent of the total power, coal, and size of boilers might be made by the use of a single-collar thrust bearing, instead of the multi-collar. The conservation of fuel which may be made by the use of the new bearings is of such magnitude that the opportunity for saving should not be neglected.

There are three designs of single-collar thrust bearings in operation on marine propeller shafts; the Michell thrust bearing, the Kingsbury thrust bearing, and the General Electric Company's spring thrust bearing. The Michell and Kingsbury bearings have segmental blocks with babbitted rubbing surfaces which have pivotal or rocking supports. In the General Electric Company's bearing, the thrust from the shaft is transmitted to a flexible plate having a babbitted surface, and then through a multiplicity of springs to the bearing housing.

Fig. 1 shows a horseshoe bearing of recent design having nine collars for supporting a thrust of 30,000 lbs. Fig. 2 shows a General Electric spring thrust bearing to carry a load of 60,000 lbs. Both of these are designed to be placed on the propeller shaft astern of the driving engines. The spring thrust bearing is designed to interchange with an old-style horseshoe thrust bearing, and is somewhat larger than would be necessary on a new installation. In Fig. 3 is shown the design of a spring thrust bearing to carry a 30,000-lb. load, and to be located on the end of the propeller shaft in a housing integral with the reduction gear case, or in the motor frame on an electrically driven ship. When placed at the end of the shaft, the diameter of the bearing plates is less which

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* Lieutenant Smith probably refers to a battleship of about 21 knots speed and a propeller speed of about 200 r.p.m.

reduces the average rubbing speed and, consequently, the friction loss. With this arrangement the space occupied by the bearing and housing, and the weight of these parts, is only about one tenth of that required for the horseshoe bearing in Fig. 1.

Spring Thrust Bearing

The distinctive feature of the spring supported bearing, is that it will automatically adjust itself to insure equal loading regardless of inaccuracies in workmanship or alignment. The springs provide a support for the flexible stationary bearing surfaces which will allow it to yield at any point that may tend to be overloaded. The details of this type of bearing are shown in Fig. 3. The thrust on the rotating collar is received by a thin babbitted plate and transmitted through numerous springs to the bearing housing. An initial compression is placed on the springs by means of washers next to the babbitted plate and the bolts pass through the springs to a base plate. The springs are compressed to a position corresponding to a little more than full load on the bearing. This restriction prevents any axial motion of the shaft, which would take place with the changes in propeller thrust if the springs were free. Under ordinary conditions the stationary bearing surface as a whole may be regarded as a solid support, except that unequal pressures on the surfaces are relieved by yielding of the thin plate and further compression of the springs behind the high spots. The clearance between the rotating and stationary plates on the idle side of the bearing is about 0.01 of an inch.

In the manufacture of spring-supported bearings, the babbitted surface does not need to be scraped to a surface plate and therefore it is machine finished. The spring thrust bearing will automatically adjust itself while running to variations in the thickness of the bearing plates and faulty alignment. The automatic adjustment of the babbitted plate to any change in alignment is particularly advantageous on shipboard where a true alignment is not maintained at all times, due to local strains to which the ship is subjected. Experience with this design of thrust bearing has proved that it will run with high unit pressures and that the weight is entirely supported on the oil film. A bearing which operates under these conditions has a high efficiency, is practically free from wear, and requires very little attention from the operating engineers.

Recent Developments in Shaft Pressing at Destination

By N. L. Rea

Construction Department, General Electric Company

Until recently the task of pressing on shafts at destination has been accomplished by improvised methods, few means, if any, having been provided by the factory. The resulting facilities have often been inadequate and a great deal of trouble and delay have ensued in many cases. This subject has been carefully studied by erecting engineers and means have now been developed for performing this operation with precision. The methods that have been found successful are described in this article.—Editor.

The pressing of fields or armatures on shafts has always been the *bête noir* of the erecting engineer's existence. Local facilities are always meager, and the customer is always in a great hurry to get the machine in service. On top of these troubles, shaft pressing is one of those jobs that has to go through regardless. If you can't get it on you certainly can't get it off, for it may take from two to two and a half times the pressure to reverse the shaft or start it forward again after it has stopped moving for any length of time. In view of these troubles, recent developments and improvements in handling this work may be of assistance. The improvements are based on the experience of our outside erecting engineers, extending over several years and with all classes of apparatus.

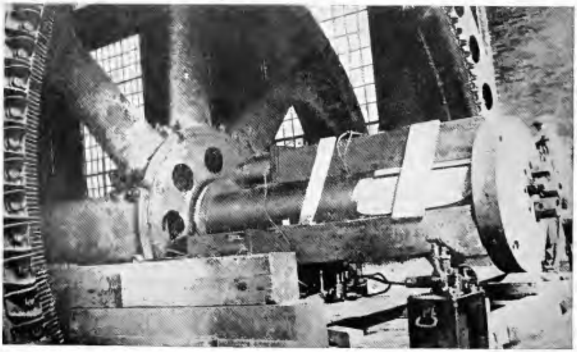

Fig. 1. Arrangement of Parts for Shaft Pressing, employing three 150-ton jacks

The old arrangement of strong backs, pull rods, and a large jack against the end of the shaft has been abandoned altogether. Instead, a large cast steel disk is bolted to the end of the shaft by several 2½-in. nickel steel cap bolts. This disk overhangs the shaft far enough to catch the heads of two, three, or four hydraulic jacks, depending on the pressure required. The jacks have a common pump and distributing manifold and come in sets of four. Two sizes are available, 100 tons each giving a maximum of 400 tons, and 150 tons each giving a maximum of 600 tons. The jacks are approximately 18 inches high and have a travel of eight inches. This dimension is much shorter than the usual length of shaft exposed when the fits are just taking up. This extra space is filled by blocking cut from the shipping skids.

Fig. 1 shows a typical pressing job, using three 150-ton jacks against a maximum load of 370 tons. Fig. 2 shows the disk with the standard drilling for the largest shafts where pressures up to 600 tons are expected. Fig. 3 shows drillings adapted for smaller shafts. The large disk shown in Fig. 2 has been drilled so that it will take any of these standard drillings.

Fig. 1 shows four bolts used on the Fig. 3 drilling. This photograph was not taken for publication, so the box wrenches were not removed from the bolt heads and large nuts were used as washers on the other two bolts.

When this scheme was first used a safe loading of 60 to 75 tons per bolt was assumed. In one case, however, the erecting man did not catch an error in hub bore and pressed on with an allowance of seven mills plus, when the fit should have been three and a half mills. The pressure gauge was cut off to save it when it reached the top scale reading of 400 tons some time before the pressing was completed. Three bolts spaced on Fig. 3 drilling withstood this load without any sign of distress.

This arrangement has not only proved cheaper, quicker, and easier than the usual practice, but works much more satisfactorily. The shaft pulls in steadily and silently without any of the customary jumping and groaning.

Several new schemes have been developed for heating before pressing, due to the heavy fits called for on high-speed machines, especially on flywheels. These were as high as 0.007 in. or 0.008 in. steel on steel. In one case 0.011 in. was called for, steel on steel. We thought these were too big to put on cold, as there was the chance that cutting might run the required pressures beyond the capacity of any jack equipment.

The first wheel was boiled for 48 hours in the following manner: A shallow tank was made of galvanized roofing iron and laid on the power house floor, and the field, less poles, was placed in this tank, resting on small blocks. The tank was then filled with water and covered. Several inches of sand was placed on the floor around the tank and a small ring fire kept burning against the side of tank. After 48 hours at boiling temperature the field was lifted out and lowered over the shaft, which had been blocked in a vertical position. This was done so that the weight of the field (30 tons) would help to put the field home. It was found, however, that the field was loose on the shaft; in fact, it was about eight hours before the field gripped. This experience was enlightening and led to considerable planning on other jobs.

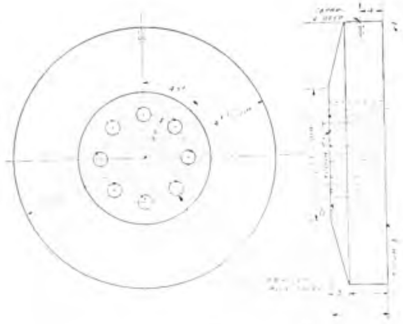

Fig. 2. Disk with Drilling for Pressing on Largest Shaft

The next job undertaken was a 30-ton flywheel. Natural gas was available, but we were afraid that heating by flame would cause uneven expansion and distort the wheel. We therefore decided that steaming was the simplest and safest process, as this would give uniform heating. The coldest part of the wheel condenses the most steam and thus automatically equalizes the temperature.

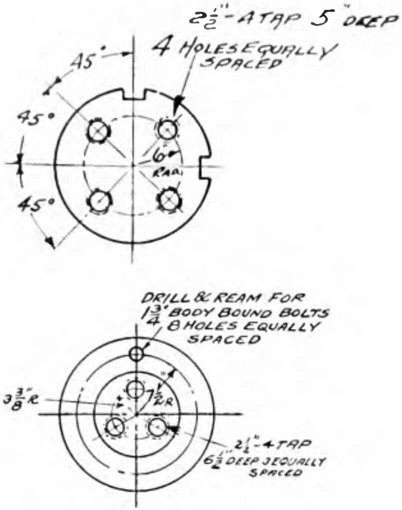

Fig. 3. Drillings for Smaller Shafts

The flywheel was blocked on its edge and enclosed in a box made from the packing case lumber. This box was held together at the corners with wedges so that it could be dismantled quickly. A ¾-in. steam pipe was led into the box, the box covered with tarpaulins, and steam turned on until it showed slightly through the tarpaulins. This heating was continued for 36 to 48 hours before starting the assembly.

The shaft diameter was used as a check and showed 0.015 in. clearance, or a total expansion of 0.022 in. The shaft was then pulled in with a chain hoist instead of using the pressing rig. The rig was, of course, connected up ready for instant use in case of emergency.

Recently we had occasion to put two large direct-current armatures on a shaft. The shaft was 35 in. in diameter, and pressing cold was expected to require a maximum pressure of approximately 600 tons. These armatures were unboxed and prepared for assembly. Several large iron grid rheostats were borrowed from the motor control equipment and placed in the bore and between the spokes.

The armatures were covered with tarpaulins and the temperature under the tarpaulins held at 80 deg. C. for several days. Tests showed ample clearance and the shaft was pulled in with a 5-ton chain hoist, the shaft being partly carried by the crane.

In this case, as in the other one mentioned, the jacking equipment was erected and tested beforehand so that it was ready for immediate use in case of need. This heating also assisted in drying the armature windings.

The above examples have served and probably will continue to serve as a basis of many variations to meet local conditions. Couplings have been boiled in iron wash tubs, or steamed in a packing case. Hub bolts for large generators are also boiled for a shrink fit. This gives much better results than heating with fire. There is no chance of scaling or burning, and the shrink on all the bolts is found to be alike.

Calculation of Short-circuit Currents in Alternating-current Systems

By W. W. Lewis

Power and Mining Engineering Department, General Electric Company

The value of being able to calculate short-circuit currents in large power networks, in order to provide and set suitable protective devices, has long been recognized. However, the mathematical methods, used in the past for securing the data necessary to this end were laborious and often impossible of application in the more complicated cases. The solution of these difficulties lay in the development of the calculating table described by the author. With this device, the complicated problems of the central station can be set up, and adequate data secured to show the weaker points of the system which can then be easily strengthened. The author illustrates the method of solving a number of these problems in a very comprehensive manner.—Editor.

Present day power networks are growing extremely large as compared with former standards. There are a number of systems with 100,000 to 200,000 kv-a. in generating capacity, and systems of 1,000,000 kv-a. are planned. Owing to the war and the stimulus of the Fuel Administration, a great many neighboring systems are interconnecting by tie lines of more or less current carrying capacity.

Short circuits on such large power systems throw a tremendous duty on oil circuit breakers and cause heavy mechanical strains in the transformers, busbars, etc. It is therefore important to be able to calculate the short-circuit currents that may exist on such systems in order to select the proper circuit breakers, and to devise relay schemes that will act selectively to cut out that portion of the system which is in trouble.

Various methods of making these calculations have been proposed. They are nearly all based on the assumption that the limitation of the short-circuit current is due almost entirely to the inductive reactance of the circuit and that the effect of resistance and capacitance reactance are negligible. That this is true has been shown by calculation, the effect of thus neglecting the resistance and capacitance reactance being to give a somewhat larger short-circuit current than would be obtained were they considered. This assumption also greatly simplifies the calculation as, instead of having to add impedances at various phases angles, reactances only need be added and these are all in phase.

Simple networks may be calculated mathematically. For complicated networks, the mathematical calculation becomes very laborious and in most cases is absolutely impractical. In such cases it is necessary to resort to a mechanical or electrical calculator. All the methods are based on the same principle which is briefly as follows:

The self-inductive reactance of the various generators, transformers, power-limiting reactors, and lines is determined and reduced to reactance drop, usually expressed in percentage of the voltage from line to neutral. In order to have the percentage reactance of the various pieces of apparatus directly additive, it is necessary to reduce them to a common base; i.e., an arbitrary value of kilovolt-amperes is assumed as base and the percentage reactance of a piece of apparatus is increased or decreased in proportion to the ratio of the basic kilovolt-amperes to the rated kilovolt-amperes. The total combined reactance from the generators to the short circuit is then found and it is assumed that the short-circuit current flowing through this total reactance produces 100 per cent voltage drop from the generator neutral to the point of short circuit. Thus, if the total reactance is 100 per cent a current equal to normal or basic current will flow. For any other reactance, the current that flows will be as many times normal as 100 divided by the total reactance. The short-circuit current may be expressed in amperes or kilovolt-amperes; the kilovolt-amperes being the product of the short-circuit current by the normal voltage, which is the voltage existing at the beginning of the short circuit or after the short circuit has disappeared.

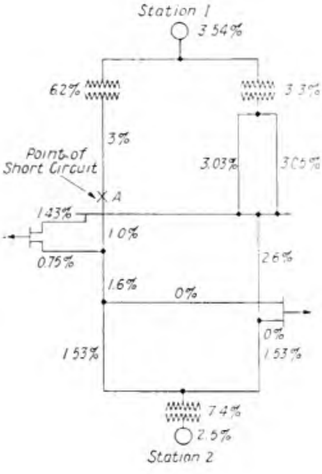

Fig. 1. Short Circuit Problem
Short circuit at A
Basic value 10,000 kv-a.

This kilovolt-ampere value is rather a fictitious quantity but is quite useful in comparing the short-circuit current with the rated current of the system; both currents being multiplied by the voltage of the system and expressed in kilovolt-amperes.

An example will be [illegible]
Assume a network [illegible]
The various portions [illegible]
per cent reactance indicated [illegible]
10,000 kv-a. Station No. 1 and [illegible]
generating station, each consist [illegible]

Fig. 2. Short Circuit Problem
Short circuit at A
Basic value 45,000 kv-a.

of generators with a combined reactance as shown. For a three-phase short circuit at A, the short-circuit kilovolt-ampere value is found as follows:

$$6.2+3 \quad =9.2$$

$$3.3+1.52=4.82$$

$$\frac{1}{\frac{1}{9.2}+\frac{1}{4.82}}=3.16$$

$3.16+3.54=6.7$ Total reactance of circuit from Station No. 1 to short circuit.

$$1.43+0.75=2.18$$

$$\frac{1}{\frac{1}{2.18}+\frac{1}{1}}=0.685$$

$$0.685+1.6 \quad =2.285$$

$$\frac{1}{\frac{1}{2.285}+\frac{1}{2.6}}=1.215$$

$$1.215+0.765=1.98$$

$1.98+7.4+2.5=11.88$ Total reactance of circuit from Station No. 2 to short circuit.

$\frac{1}{\frac{1}{6.7}+\frac{1}{11.88}}=4.29$ Combined reactance from Stations Nos. 1 and 2 to short circuit.

$$\frac{100}{4.29}\times 10{,}000=23.3\times 10{,}000=$$
233,000 kv-a. at short circuit

The proportion of this amount furnished by Station No. 1 and Station No. 2 may be found as follows:

$$\frac{1}{6.7} = 0.1490$$

$$\frac{1}{11.88} = 0.0842$$

$$0.1490 + 0.0842 = 0.2332$$

Fig. 3. Table Showing Method of Mounting Rheostats, Ammeters and Terminal Blocks

Station No. 1 =

$$\frac{0.1490}{0.2332} \times 233{,}000 = 149{,}000 \text{ kv-a.}$$

Station No. 2 =

$$\frac{0.0842}{0.2332} \times 233{,}000 = 84{,}000 \text{ kv-a.}$$

In like manner, the proportion of these kilovolt-amperes that flows over each individual portion of the circuit may readily be determined. The kilovolt-amperes divided by the normal voltage will give the amperes flowing under short circuit.

Fig. 2 shows a more complicated network in which a number of generators feed a common bus at points separated by busbar reactors. The percentages of reactance given are based on 45,000 kv-a. The short circuit occurs at point A.

The solution of this problem is rather involved. It may be accomplished by setting up a number of simultaneous equations based on the assumption that the initial voltage of all the generators is equal, and that the total voltage is consumed from any generator neutral to the short circuit, together with the law that the currents flowing toward a point are equal to the currents flowing away from the point. The more or less laborious solution of these equations will give the currents flowing in the various circuits for the short circuit at one particular point. If a short circuit at another point is to be considered, a new set of equations must be set up and solved. Where much of this class of work is done, it is highly desirable to have a simpler and quicker means of solving these problems. This is afforded by the so-called "calculating table," described in the October 1916 General Electric Review, page 901. The problem of Fig. 2 has been solved in this manner with the results indicated.

By means of the calculating table a miniature representative system may be set up and a short circuit placed on it at any point; current being read in any element of the circuit. For the study of relay settings, a set of readings may be taken from which it is determined that a certain switch should open. This switch may be opened on the table and a new set of readings taken and this process repeated until the short circuit is cleared. The original table, Fig. 3, described in the October 1916 General Electric Review was found inadequate for some of the complicated modern systems and it has since been enlarged as shown in Fig. 4. This photograph was taken with the table set up for the study of a large proposed transmission network.

The current I_o obtained by the method of calculation described, represents instantaneous amperes or, more correctly speaking, the effective initial value of the alternating component of the short-circuit current, and if the wave is symmetrical about the zero axis, this is the initial effective or root-mean-square value of the wave of total current. If the short circuit takes place at no load and at such a point on the voltage wave that the current wave is completely offset above or below the zero axis, the initial effective value of the wave of total current is 1.73 times the symmetrical value, or $\sqrt{3}\, I_o$*. At full load this valve is somewhat less. As there is a possibility of the short circuit taking place at any point of the voltage wave between zero and the maximum, thus giving a current wave completely offset, symmetrical or any-

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* See article entitled, "Reactance and Short-circuit Current" by R. E. Doherty, General Electric Review, August 1918, p. 562.

where between these extremes, it is necessary to figure on the worst condition or initial effective value of current equal to $\sqrt{3}\, I_o$.

From this value the current decreases to a constant or sustained value in about two to three seconds, as shown by curves given in the paper entitled, "Rating and Selection of Oil Circuit Breakers," by Messrs. Hewlett, Mahoney, and Burnham, *A.I.E.E. Proceedings*, February 1918, which curves were reproduced in Mr. Doherty's article previously mentioned.

As shown by Mr. Doherty, the current I_o may be found by dividing E, the effective value of the leg voltage, by the sum of X_o, the total self-inductive reactance per leg of the generator in ohms, or transient reactance, and X_{ex}, the total self-inductive reactance per leg of the apparatus external to the generator, such as transformers, reactors, and lines.

Likewise, the sustained current I_s may be found by dividing E, the effective value of the leg voltage, by the sum of X_s, the sustained or synchronous reactance of the generator (i.e., the self-inductive reactance plus the armature reaction), and X_{ex}, the total self-inductive reactance of the apparatus external to the generator.

In order to combine external reactance with sustained reactance of the generator, it is necessary that both values be expressed in the same terms, a convenient base being normal voltage and current. The normal per cent sustained reactance of the generator $= \frac{100\, I_n}{I_{sc}}$, in which I_n is the normal current and I_{sc} the short-circuit current corresponding to F_1, the excitation for normal no-load voltage on a straight-line magnetization curve. If the short circuit occurs when the generator is operating under load conditions, the excitation F_2 will be greater than F_1 and the short-circuit current corresponding to the combined external and generator reactance must therefore be increased in the ratio F_2:F_1.

It is obvious that the field setting of each generating station must be known in order to apply a correction to the sustained reactance for calculating the sustained short circuit.

The curves in Messrs. Hewlett, Mahoney, and Burnham's paper give effective or root-mean-square values of the unsymmetrical wave; the curves being based on the condition that the alternator is carrying full load at 80 per cent power factor. In our Figs. 1 and 2, the value calculated is the effective or root mean-square value of the symmetrical wave at the beginning of the short circuit, based on instantaneous or transient reactance. This value may be connected with the curves in the Institute paper in the following manner:

Fig. 4. Calculating Table Arranged for Transmission Line Study

In Fig. 2 the total rated capacity in generators Nos. 1 to 5 inclusive is 212,000 kv-a. and at the point of short circuit 561,000 kv-a. The total reactance is

$$\frac{212{,}000}{561{,}000} \times 100 = 37.8 \text{ per cent}$$

Interpolating on Figs. 2 and 3 of the Institute paper between the curves of 30 and 40 per cent reactance, we find the short-circuit current in say 0.2 seconds to be 2.44 times normal, and 2.44 times 212,000 equals 518,000 kv-a. In three seconds the short-circuit current is 1.75 times 212,000 which equals 371,000 kv-a. In this example, therefore, we have the following values based on no-load conditions:

Instantaneous effective value, symmetrical wave

$$I_o = 561{,}000 \text{ kv-a.}$$

Instantaneous effective value, unsymmetrical wave

$$1.73\ I_o = 962{,}000 \text{ kv-a.}$$

Peak value first half cycle, unsymmetrical wave

$$2\sqrt{2}\, I_o = 1{,}590{,}000 \text{ kv-a.}$$

Also the following values based on full load 80 per cent power-factor conditions:

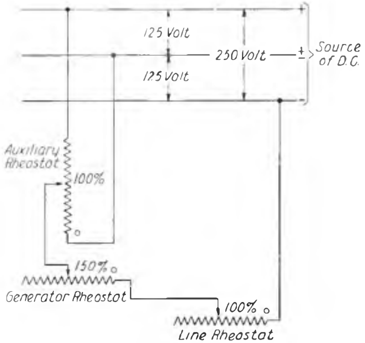

Fig. 5. Manner of Connecting One Generator, One Line, and One Auxiliary Rheostat of Calculating Table Illustrated in Fig. 5

Effective value at 0.2 seconds = 518,000 kv-a.

Effective value at three seconds (practically sustained) = 371,000 kv-a.

The effective values at various other lengths of time may likewise be found. These are useful in determining the amounts the switches are called upon to rupture with different relay settings, while the peak value $2\sqrt{2}\, I_o$ is the value that must be considered in determining short-circuit forces.

A calculating table, Figs. 6 and 7, has been built for one of the large power companies embodying many convenient features not incorporated in the table shown in Figs. 3 and 4. Connections are made between the rheostats, representing the different elements of the system, by means of telephone jacks and receptacles. The ammeter is connected to a bus with the wiring so arranged that the current in any element of the system may be read by simply pressing a key. This table is designed for operation on 125/250-volt, three-wire direct current, 125 volts being normal. The feature of sustained short circuit is taken care of by having auxiliary rheostats of one thirtieth the resistance of the generator rheostats. By means of these auxiliary rheostats, the voltage of each generator may be regulated from normal to 100 per cent above normal, thus giving the effect of increased field setting for full-load conditions. It is obvious that the effect of automatic voltage regulators may also be taken care of by this feature. Fig. 5 shows diagrammatically the connections for one generator, one line, and one auxiliary rheostat.

The calculating table described in the preceding paragraph is complete in all its details, and readily makes possible the determination of short-circuit currents in complicated power networks.

A comparison of this calculating table with those shown in Figs. 3 and 4 will indicate its many improvements, not only in appearance but particularly in the simplicity of connecting it up for a transmission system problem, and the making of the necessary test readings for the problem's solution.

All the previous remarks refer to three-phase short circuits. Single-phase short circuits require a somewhat different and more complicated treatment. The case of a short circuit due to a ground on one line of a grounded neutral system has been treated briefly by the writer in an article entitled, "Short-circuit Currents on Grounded Neutral Systems," General Electric Review, June 1917, p. 524, and it is hoped that this subject may be gone into more fully in the near future.

Fig. 6. Front of Improved Calculating Table Built for a Large Power Company

In the paper just referred to mention was made of the possible effect of line capacitance on the currents flowing when the system was short-circuited from line to neutral.

Some tests have since been made on a 110,000-volt transmission line which show the presence of such capacitance currents. The tests in question were made with a 13,500-kv-a., 6600-volt generator, a 13,500-kv-a. transformer bank stepping up from 6600 volts delta to 110,000 volts Y, the high-voltage neutral being grounded, and various lengths of open transmission line. Short circuits were made by placing a ground on one conductor or by short-circuiting between two conductors; the short circuit usually being placed near the generating station. In some cases the current read on the ungrounded or unshort-circuited line equalled or exceeded that on the short-circuited line. With a certain combination of generator, transformer, and transmission line, an interesting case of resonance was noted; i.e., with the generator and transformer bank and about 50 miles of line the curve of charging current of the ungrounded or unshort-circuited line rose to a sharp peak, the values decreasing with shorter and longer lines. This is shown in Fig. 8, which gives the short-circuit current and charging current for the two conditions:


Fig. 7. Back of Improved Calculating Table Built for a Large Power Company

(a) Short circuit, bottom to middle conductor.

(b) Ground on bottom conductor.

The peak in the charging current curve is probably due to triple frequency resonance caused by the liberation of a third harmonic component of voltage between lines. This occurs because the third harmonic components of the leg voltage at the generator no longer neutralize each other, owing to the partial collapse of the leg voltage under short circuit. This is confirmed by calculation of the natural frequency of the generator, transformer bank, and various lengths of line. This calculation shows that the natural frequency of the generator, transformer, and 50 miles of line is about 180 cycles, which is three times the normal frequency of this system. Thus, if there were a third harmonic of voltage present under these conditions, resonance would result. The effect of this charging current in some cases is of sufficient importance to be taken into account when considering the operation of relays.


Fig. 8. Short Circuit and Charging Currents on Transmission System Consisting of One 13,500-kv-a. Generator, One 13,500-kv-a. Transformer Bank with Grounded Neutral, and Various Lengths of Line

REFERENCES

"Approximate Solution of Short-circuit Problems," by E. G. Merrick, General Electric Review, June 1916, p. 470.

"An Approximate Method of Calculating Short-circuit Current in an Alternating-current System," by H. R. Wilson, General Electric Review, June 1916, p. 475.

"A Device for Calculating Currents in Complete Networks of Lines," General Electric Review, October 1916, p. 901.

"Short-circuit Currents on Grounded Neutral Systems," by W. W. Lewis, General Electric Review, June 1917, p. 524.

"Rating and Selection of Oil Circuit Breakers," by Messrs. Hewlett, Mahoney, and Burnham, *A.I.E.E. Proceedings*, February 1918.

"Reactance and Short-circuit Current," by R. E. Doherty, General Electric Review, August 1918, p. 562.

Methods for More Efficiently Utilizing Our Fuel Resources

PART XXIV. THE USE OF ELECTRIC POWER IN THE MINING OF ANTHRACITE

By J. B. Crane

Lehigh Power Securities Company, Allentown, Pa.

This paper gives figures as to the power cost and current consumption of anthracite mines and the reasons for these being in excess of the requirements of bituminous mines. Estimates are also given as to the additional coal that will be released by the electrification of the anthracite mines. Illustrations are included showing representative installations of electric drive.—Editor.

The production of anthracite in the United States during the past five years was as follows:

Years	Total Gross Tons
1913	81,809,782
1914	81,580,479
1915	79,803,374
1916	78,406,387
1917	89,720,982

The undeveloped beds are to such a large extent owned or controlled by the large producers, that no extensive opening of new mines has taken place in recent years nor is to be expected in the near future.

In the bituminous fields there are many independent holdings and when the coal business was flourishing many new companies were formed and opened up mines, using electric drive, mainly on account of lower first cost for installation of machinery. The resulting economies were such as to force the former steam-operated mines to electrify, even where it was necessary to throw away expensive steam equipment.

Coal producers are conservative and, not having the many examples of successfully operated electrified mines before them, the anthracite operators have been slower to see the benefits to be derived and the economies to be effected by throwing out their steam equipment and replacing it with electrical equipment. Also, the margin of profit due to the better organization of the producers was higher and the necessity of economy in production had not been brought home to them with the same force.

The anthracite industry, therefore, offers greater opportunities for the further application of electric power than can be found in the bituminous coal mining industry. The principal gains which will follow are:

1. Less coal consumed for operation.
2. Increased production.
3. Less labor required.
4. Better living conditions for employees.

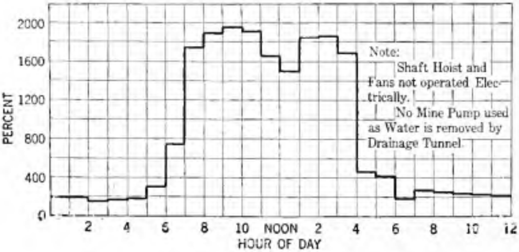

Fig. 1. Typical Breaker Load and Mine Haulage

The anthracite operators are at the present time keenly alive to this fact and are making every effort to take advantage of the improvements to be made by electrification of their mines, but are handicapped by the difficulty of securing electrical equipment and by the impossibility of securing sufficient power from the central stations supplying power to the anthracite regions.

The mines that have been electrified show some surprising results. The figures in Table I are taken from a paper read before the A.I.M.E. (Economy of Electricity over Steam for Power Purposes in and about Mines, by R. E. Hobart, Feb. 18, 1918).

When it is remembered that the value of the coal burned with steam operation has more than doubled and that the output of coal per man per year employed has increased from 540 tons to 647 tons it will be seen that the figures, large as they are, represent only part of the saving to be effected

required for ventilation, quan[illegible] to be pumped as well as the [illegible] seams, and amount of [illegible] to prepare coal for market. [illegible] three years ago required from [illegible]

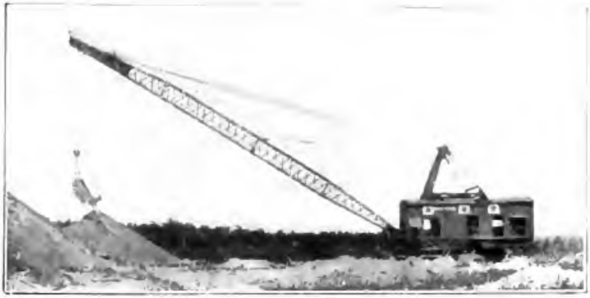

Fig. 2. An Electric Shovel. Current supplied through a bank of three 100 kw., 4000 40-volt transformers

Some other figures obtained and given in Table II are interesting as showing costs of electrification, power used, etc.

Mine No. 2 had a boiler plant of 800 h.p., used 900 tons of coal per month, and 11 men have been put to other work about the mine. The output will be largely increased this year as the investment provides for additional equipment not yet in operation.

Mine No. 1 has no pumping, hence the low kilowatt-hour per ton mined.

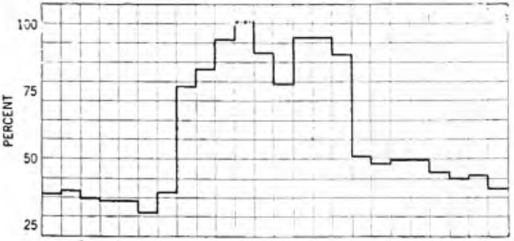

Fig. 3. Typical Anthracite Mine Load

The best figures that the writer has yet been able to obtain indicate that 12 kw-hr. per gross ton of coal mined is the average figure for an anthracite mine. This is of course subject to wide variations in individual cases on account of depth of mine, amount of air

50 bituminous mines, and it is interesting to note that the average kilowatt-hour per gross ton mined was 3.57.

The less power required for mining bituminous coal is due to various causes, among which may be mentioned:

Depth of Mine

Bituminous mines in many cases are situated above the tipple, so that the coal is brought to the surface on level tracks, and from this point is loaded into the cars by gravity, while the anthracite mines are from 300 ft. (91.4 m.) to 1000 ft. (304.8 m.) in depth and all of the coal has to be raised to the surface and from there to the breaker.

Pumping of Water

The anthracite mines have more water and this has to be elevated from the lowest level.

Ventilation

In spite of the fact that there is less volatile matter in anthracite there is generally more gas to be taken from the mine, and a larger amount of ventilation has to be provided for and the additional space used for shafts, etc. has to be ventilated.

Preparation

The breaker of the anthracite mine requires more power as the coal is sized to a greater extent than is bituminous coal.

One anthracite mine had meters installed for the different services for one year and the average figures in Table III were obtained.

This represents 38 per cent on an investment of $36,000,000.

At the present time the mining companies are prosperous and are installing, as rapidly as possible, electrically driven machinery for increasing production and cutting down the requirements for labor. They cannot at this time secure the material for power houses, and the central stations are prevented from supplying this power by the impossibility of securing the necessary capital to add to their facilities. It is suggested that means should be found for supplying the amount required to finance additions to these plants so that the vital needs of this industry for power can be met.

This mine produced 558,394 tons for the year.

If we assume 12 kw-hr. per ton of coal produced, there would have been required in 1917 if all the coal had been produced electrically		1,076,652,000 kw-hr.
There was actually used in 1917 in electrically operated anthracite mines from central station and mine plants		215,000,000
Total kw-hr. necessary to produce remainder of coal electrically		861,652,000
At the present time ten per cent of the coal produced is used to provide power to mine the remainder. There are some very bad cases, at one colliery 400 tons of coal is burned in the boiler plant for every 1000 tons of coal shipped. The above ten per cent does not include the coal used at central stations so that to produce the 89,720,982 tons in 1917 there was burned under boilers		8,972,000 tons
In large stations we can produce one kw-hr. for 2.5 lbs. of small anthracite coal (2.5 × 861,650,000 divided by 2240)		965,000
There would be released for sale		8,007,000 tons
At one colliery 2.5 per cent of the men were released by electrification. There are employed in the anthracite region 150,000 men. If 2.5 per cent are released by electrification this makes a total of 3750 men additional which would be put to mining coal. Each man produces 550 tons per year so we should get additional (550 × 3750)		2,062,500
Additional coal produced by total electrification		10,069,500
The cost of providing for this is estimated as follows:		
Additional kw-hr. required		861,652,000
At 40 per cent load-factor this represents a station capacity of		394,000 kw.
Cost of plant at $75 per kw.		$29,550,000
Transmission and distribution lines 250 miles at $5000		1,250,000
		$30,700,000
Substation and mine installations 900,000 h.p. at $40 per h.p.		$36,000,000
The savings to be effected would be 10,069,500 tons of coal at $2 per ton		20,139,000
Reduced mining cost 700,000,000 tons at 7 cents per ton		4,900,000
		$25,039,000
870,000,000 kw-hr. (861,652,000 plus losses) at 11 mills for current delivered at mine	$9,570,000	
Depreciation five per cent on $36,000,000	1,800,000	
		11,370,000
		$13,669,000

TABLE I

	Steam Operation April 1914 to April 1915	Electrical Operation Nov. 1916 to Nov. 1917
Cost of power	$46,992	$21,590
Cost of heating	Included in above	8,700
Total	$46,992	$30,290
Tons of coal mined	343,665	435,073
Cost per ton	$0.137	$0.0696

TABLE II

Item	Mine No. 1	Mine No. 2
Gross tons; yearly	641,533	670,000
Kw-hr. consumption	2,312,195	3,477,876
Kw. demand	870	1,135
Annual load-factor	30.4	35
Kw-hr. per ton mined	3.6	5.2
Kv-a. trans. capacity	2,000	3,500
H.p. connected	2,400	2,535
Cost of electrification	$134,500	$325,000
Cost per h.p. connected	56.04	128.20
Per cent kw-hr. per pumping	..	50
Average depth of mine	650 ft. (198.1m.)	800 ft. (243.8m.)

TABLE III

Operation	Kw-hr. per gross ton of coal produced
Haulage	1.73
Ventilation	1.62
Drainage	1.30
Lighting (inc. charging station)	0.12
Hoisting	1.02
Air compressor	2.11
Breaker	4.75
	12.65

PART XXV. THE NEED FOR A CONSTRUCTIVE ECONOMIC POLICY IN DEVELOPING THE COAL PRODUCTS INDUSTRY*

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Coal constitutes over a third of the country's freight. Efficient transportation calls for the full utilization of the material hauled. Coal is not only a source of energy; it is also a source of many valuable mineral products. Economic conditions have been such that American industry has neglected opportunities for multiple, or by-product, production. This field has only recently been fully opened, and the complexities incident to the development of secondary industries to utilize the by-products call for a constructive economic policy.—EDITOR

Relation of Power to Transportation

The United States places special emphasis upon the use of power. With national prosperity, abundance of resource wealth, and dearth of labor, American industrial enterprise has naturally turned to the creation of labor-saving machinery and provided for its efficient employment through the medium of standardized volume-production. To support this situation, this country consumes nearly half of the world's output of coal and over half of the total production of petroleum, not to mention the employment of water power, natural gas, and minor sources of power.

This unprecedented consumption of power, of course, places a heavy strain upon transportation, both directly by virtue of the bulk of the power materials to be moved—coal alone represents over a third of the country's freight—and indirectly in respect to the haulage of materials and products involved in the industrial processes. The responsibility thus falling upon transportation is added to in further degree by the size of the country.

Since power is a mineral derivative, the mineral industries provide a logical field for comparison. The efficient transportation of mineral products calls for the full utilization of the material hauled. American economic practice has regarded this, along with the advance elimination of weight, as a matter to be left to industrial determination and application. This policy is natural enough and, in general, works out satisfactorily, for the two principles are complementary. What is usable at the manufacturing end obviously determines what represents value and non-value at the raw material source; conversely, the degree of separation practicable at the source specifies the range of material for which use is to be sought. The whole epoch-marking development in the field of by-product manufacture finds much of its stimulus in the effort to derive returns from what would otherwise be the waste in transportation. But, with certain notable exceptions offered by some of the large industrial combinations, there is much to be desired and little to be proud of, so far as American achievement in this direction goes. The superfluous transportation that results from the failure at the manufacturing end to make full utilization of the whole range of values held in the raw material hauled amounts to many millions of tons each year. Instances are plentiful where the loss is due to a blind nonrecognition of opportunity on the part of the interests directly concerned. But in the main the default rests upon the inadequacy of American economic practice, which relies upon competition and the automatic working of the natural law of supply and demand to bring all good things to pass, neglectful of the fact that in the by-product realm supply is conditioned otherwise than by demand, that pending the creation of a proportionated demand the discrepancy of overweight on the side of supply is rejected as waste.

In such manner have three principles of transportation developed. In the realm of common carriage by railways, competition has been found to be out of place and is no longer relied upon, community interest taking its place. In the realm of advance preparation, competition has proved effective and its free operation there is desirable. In the realm of full utilization, competition alone

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* Extract from U. S. National Museum Bulletin 102, Part 5; "Power: Its Significance and Needs." 1918.

has been unable to achieve adequate results; and the need for constructive help to make competition effective here is coming to be recognized.

FULL UTILIZATION OF POWER MATERIALS

Rôle of Mutiple Production

The power materials are coal, oil, and water, and, in the present connection, it is desirable to examine how fully the amount transported is utilized. Water, of course, is not carried considerable distances for purposes of power generation and therefore presents no problem in this connection. Oil, on the contrary, is in part inadequately utilized, but this matter involves many complexities.* This limits our consideration, under the present head, to coal.

Current demand calls for the annual transportation and distribution of about 700,000,000 tons of coal and the demand is increasing at the rate of some 50,000,000 tons each year.

Primarily this enormous amount of coal is now consumed in order to gain the energy contained in it, all else being disregarded. But coal is something more than energy in material form; it is also a source of many valuable mineral products. Indeed, it is a veritable treasure house of values, in this regard far surpassing any other type of mineral substance, with the possible exception of petroleum. Upward of a thousand coal products are in use today, some of them filling needs less conspicuous but every bit as vital as that for fuel. And the development is still in its infancy. A few years ago and few of these products were known. Chemical vision can see no limit to the further unfoldment in prospect. The boundary to this field is like the horizon, always in sight but never to be reached. There can be no full utilization of coal which fails to take these matters into account.

At the present time a very small proportion of the coal consumed is adequately used. Putting to one side anthracite, which has an energy value merely and therefore yields a reasonable service in its crude state, and counting off about one twelfth of the bituminous coal, the portion subjected to by-product recovery in connection with the manufacture of coke, we find that there still remains each year in round numbers a half billion tons of coal which are consumed in the raw condition with a total loss of the commodity values and an incomplete recovery of the energy.

The question naturally arises, why this preponderant inadequacy in coal utilization? This is no simple matter to explain: the reply that the individual user, whether an industry, a community, or a householder, finds it cheaper to consume raw coal than to dispose separately of its various values is true, but superficial. That procedure is not cheaper for the users in the aggregate; also there is no lack of technological knowledge requisite to fuller recovery of the values in coal. The shortcoming, then, cannot be due to lack of desirability or to lack of technique. The default must be credited against economic conditions. And since the United States in the past has possessed no activities engaged in shaping and stimulating industrial developments, the responsibility reduces itself to the fact that industrial enterprise has not seen fit to go into the matter. Either the opportunity has not been apprehended or industrial enterprise, cognizant of the situation, has not been interested. The latter is undoubtedly the true explanation. For this lack of industrial initiative a blend of several factors is responsible. In the first place, America has been full of opportunities for volume production, and consequently business enterprise has not been forced by the stress of narrowing industrial opportunities to turn to the far more complex field of multiple, or by-product, production; only where the opportunities afforded in this direction were outstanding and marked has the inducement been responded to, as in the case of by-product coking, petroleum refining, etc. Secondly, any given project, on contemplating the prospect, faced a situation in which the establishment of production would yield by-products, the consumption of which required other industries which in turn would contribute other products calling for still further activities; hence a project at the source would undoubtedly see their contemplated output ranging off into hypothetical regions not yet established; while a project, viewing the matter further out, would regard its proposed position as bearing some resemblance to an island in a sea of nondevelopment. The requisite reach of co-ordination was evidently not self-accredited on the part of industrial enterprise. Then, again, the field has opened up fully only of late, so that the full measure of the opportunity has not been long standing.

In addition to these considerations, there has been no competitive spur to action. The loss represented in the wasteful consumption of raw coal was not felt by any

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* These will be treated in a future article of the series.—Ed.

given industry, since the practice was universal and the cost under this head was a more or less uniform item which was shifted in its entirety to the shoulders of the consuming public. The need for advance was also not generally appreciated, inasmuch as there was plenty of fuel, transportation difficulties had not loomed up, coal products could be purchased from Germany, nitrate could be imported from Chile, and, in general, the whole matter of coal was taken for granted.

Hence industry had no particular incentive for entering into a new field which, while large, was intangible; moreover industry, under the old order, faced decided limitations in its recognized inability to construct a *proportionated* demand for the whole range of prospective products. On the other hand the public, which was actually paying the cost of the inadequacy, but under a disguised heading, did not see its concern in the matter, nor was public interest represented by machinery charged with acting on popular behalf; the Federal Government, lacking the pressure of public opinion, did not take up the issue. So the course of progress was short-circuited, and the tremendous possibilities in our unrivaled coal resources remain today practically untouched. The industrial progress of this country has been sustained by the mining of an ever increasing quantity of coal, until the very bulk of the total has become a critical weakness in this country's industrial life.

Such is the situation. The utilization of coal is wasteful from beginning to end, the wastefulness is a matter of uniform practice not subject to improvement through avenues of individual enterprise, and, contrary to general notions, it is the public at large, not industry itself, which stands the loss from the shortcomings in the situation and which is, therefore, primarily concerned in its betterment.

Improvement in coal utilization, then, cannot be relied upon to come from industrial stimulus alone, but must be brought into effect as the result of public interest in the matter. The means for starting toward this accomplishment have been set forth* as lying in the direction of enlarged municipal gas plants which will handle all the coal needed by the community with the production of solid fuel, gas, and the by-products, ammonia, benzol, and tar.

Through the principle of multiple production, therefore, coal can be forced to render up its full quota of service. This is a new economic force, one scarcely recognized as yet as a principle which may be constructively applied. Yet the principle of multiple production has been gaining headway for years and by means of it the multiplying needs of man are being met from practically a stationary range of raw material. The rôle of multiple production is rapidly enlarging; it represents a principle that must come into play more and more to relieve the strain falling upon natural resources and transportation. Through the agency of chemical knowledge it serves to create a divergence of products, each the starting point of a second diverging series. The principle of multiple production is peculiarly applicable to coal and oil; only by the use of this principle, brought into effective action under the guidance of a constructive economic policy, can adequate value be extracted from these power materials.

The principle of multiple production and the principle of electricity are the two most important economic forces that have come into play during the current industrial order. Nothing since the introduction of steam power can be compared with either of them in significance.

Of the two, electricity has made the greater headway; multiple production has not yet found an opening outside the confines of the coke industry and has succeeded in pre-empting only half of that field. The gas industry weighs but lightly in this connection as it consumes only about one per cent of the bituminous coal production, and in this field multiple production has scarcely started. The principle of multiple production, however, spells the future—the only future, but that a great one—for the gas industry.

In the realm of power these two great agencies of economic advance are exactly complementary. Together they present a solution for the transportation aspects of the power problem, not to mention their bearing in other regards. The principle of multiple production enables the full utilization of the whole range of values transported in the form of coal. Electricity makes it possible to transmit *energy* where energy alone is required and thus frees the ordinary channels of transportation of a needless burden of bulk haulage.

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* Part XXIII of this series, GENERAL ELECTRIC REVIEW, Jan., 1919.

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