CURREND! Mia WOtRICADE NMWSY 6.56 obs. cos Sie Sea deigehaleldian oaeslas 489 proper burning of the coal. This feature has received a lot of attention from boiler house operators, but generally dependence

REVIEWS OF CURRENT ENGINEERING AND SCIENTIFIC LITERATURE. 


FUEL ANALYSIS FOR STEAM USERS. 

RADIOACTIVITY AND FUTURE POWER SUPPLY. The recent controversy aroused in England over the subject of radioactivity is dealt with at some length in Engineering. London, August 31, the following interesting conclusions being drawn:

Of course, like any other physical theory, this one of atomic disintegration may, as observations accumulate, prove unequal to the description of new experiments; but, as matters stand, no competing explanation of the phenomena involved seems to cover and unify so wide a range of observed facts, and it will certainly not be abandoned until some other hypothesis is developed which will afford an equally intelligible and adequate model of the internal structure of the atom. The whole question is in its infancy, and much light may be expected during the next few years. Though, at the present time, the matter is of no immediate practical importance, the material interests of the race are involved in no remote degree. Our present civilization is based upon the possession of coal, and the output of mechanical power is increasing rapidly from year to year. In the no very distant future the supply of this indispensable commodity will be exhausted, and unless the human race can find some other source of energy, a relapse into barbarism seems inevitable. Recent experiments at Cambridge go to show that it may not prove wholly impossible to unlock the enormous reserves of internal energy which, on the hypothesis now under debate, are assumed to be locked up in the atom; though, in the experiments in question, this release of energy is only effected to a degree but little removed from the infinitesimal.

The controversy over the new theories of radioactivity can be settled only by continued experiment and it is the duty of their opponents, as well as of their supporters, to produce experimental evidence. Mere discussion, while helping to clear away misunderstandings, does not add to our knowledge. What are needed are facts and a mind to correlate them.

The suggestion of a faint possibility that one day we may become independent of coal may bring a grain of comfort to those, if any there be, who are worrying over our future needs, but it does not give us license to go on indefinitely in the wasteful methods of to-day.

FUEL ANALYSIS FOR STEAM USERS.

On a number of occasions attention has been called to the importance to steam users of paying more attention to their fuel. Coal, as any other commodity, varies in value, even when taken from a single mine, and since its cost is one of the large items of the operating expense of the boiler room, it is fair neither to the purchaser nor to the seller to pay a fixed price, no matter what the condition or what the quality of the coal delivered.

Another important item in boiler house economy is the proper burning of the coal. This feature has received a lot of attention from boiler house operators, but generally dependence has been placed upon old notions, and only of late has thought
been given to the chemistry of the process, which is, of course, of the greatest importance.

Another problem of consequence in the boiler house is the procuring of pure water, for if this be not available either the tubes of the boilers become coated and lose in efficiency or a water-softening process must be employed. In either case the engineer in charge should know just what is the character of the water he is using.

These three questions—the purchasing of the fuel, the burning, and securing pure water—all involve chemical problems, which, although not intricate, are not generally familiar to engineers. Their importance is, however, now becoming realized, and it is not at all difficult for any one with any scientific training at all to become sufficiently skilful in the analysis of coal, of chimney gases and of water to enable him to know just what he is getting and how his boilers are behaving. With the object of furnishing this information the Electrical Review has secured from Mr. John B. C. Kershaw, a series of articles on “Fuel, Water and Gas Analysis for Steam Users.” The first instalment appeared in the issue of September 8.

Mr. Kershaw is a widely-known analytical chemist, and has had a large experience in engineering work. He treats the subject from the standpoint of the steam user, and not from that of the theoretical chemist. All the information that is needed for successfully carrying out this work, so that the operation of the boiler house may be put on a scientific basis, will be given in this series.

THREE-PHASE AND DIRECT-CURRENT TRANSMISSION SYSTEMS COMPARED.

An interesting and instructive comparison between the three-phase system of electrical transmission of power and that known as the Thury system, which employs direct currents of high potential, has been made by Signor Giacinto Motta, of the University of Milan, on behalf of the city council of that city. The city of Milan owns a municipal lighting plant and has acquired certain water rights on the upper Adda river. In order to utilize these Signor Motta was retained to investigate the advantages of the two systems of transmission and decide between them.

His report is given in abstract in the Electrician (London), August 24. It is in favor of the three-phase system.

The water rights to be utilized make available 38,200 horse-power at the turbine shafts, which, it is thought, should make available at Milan 28,000 kilowatts at the secondaries of the transformers. The transmission line will be ninety miles long and will pass over the Orobie Mountains at a point 3,500 feet above the sea level. The comparison was made on a basis of 130,000 volts direct current, and 60,000 volts alternating three-phase current.

The Thury system would consist of ten generating groups, each made up of four alternators driven by one turbine. The voltage limit of each group was to be 15,000. At the receiving end, direct-current motors were to be employed, driving generators for local distribution. The three-phase system was to consist of a number of alternators operated in multiple in the usual way, with a frequency of forty-two cycles.

Considering first the efficiency of the two systems based on a full load of 28,000 kilowatts, that of the hydraulic system is the same for both methods. With the continuous-current system the efficiency of the line was estimated at 95.3 per cent, while for the three-phase system it was ninety-one per cent. The former system loses, however, due to the method of distributing to the secondary systems. The efficiency of the motors was taken at ninety-two per cent, and that of the alternators at ninety-three per cent.

The overall efficiency of the continuous-current system was computed to be fifty-three per cent, which is about three per cent less than that found for the three-phase system, the latter being 55.8 per cent. On this count, therefore, the three-phase system wins.

Coming next to the cost of the two systems, Signor Motta finds that the cost of the continuous-current system would be about $2,000,000, and that that of the three-phase system would be $2,032,000, a difference in favor of the direct-current system of 1.6 per cent. These costs include those of the generating equipment, the line and the substation apparatus.

It is interesting to point out that although the costs for the two systems are so nearly the same, there is a considerable difference in the various items. For example, the operating machinery for the direct-current system was put down at $1,400,000, while the line is charged at $600,000. For the alternating system the machinery was estimated to cost $750,000, while the line, including the lightning arresters and similar auxiliary appliances, was charged at $1,242,000. The calculated cost for the substation machinery alone for the Thury system was $720,000, while that of the transformers for the three-phase system was not over $175,000. The three-phase line was to consist of three wires, each having a cross-section of 340 square millimetres (480,000 circular mils), and the direct-current line was to consist of four wires, two for each side, each having 140 square millimetres (280,000 circular mils) cross-section.

One feature which had great weight in deciding in favor of the three-phase system was that the plans for the Thury system called for 104 commutators in series, and thus, while this system undoubtedly gains in simplicity so far as the line and switchboard apparatus is concerned, it loses more than it gains when this feature is borne in mind. The advantages claimed for the direct-current system are economy in line construction and simplicity in regulation. While it may be a simpler matter to control and maintain constant the current at the generating station than to maintain constant potentials at various points a hundred miles or so away, this large number of commutators in series certainly forms a weak point in the system which would probably not infrequently give rise to troubles, not only upsetting the regulation but interrupting the service. In this particular instance the economies in the line barely offset the increased expense of substation apparatus. If the transmission line were longer, the advantage of the direct-current line would be more pronounced; but reliability is equally as important as economy,
and the direct-current system labors under the disadvantage that it has been tried in but few instances. It is true that a system of this kind has recently been put in service in southern France, but this makes only the second or third system of any importance, and as against this may be mentioned the large number of three-phase systems both in this country and in Europe. The Thury system was under consideration for the proposed Victoria Falls transmission in South Africa, where the great distance over which the power has to be carried makes the cost of the line a controlling factor; but as yet no definite plans for this undertaking have been given out. Signor Motta’s comparison is of much interest, and there seems to be no question that his decision is correct, but one can not assert from this that the three-phase system will be the better under all conditions, although from present knowledge it must be admitted that it is looked upon far the more favorably.

THE ACTION OF ELECTRICAL OSCILLATIONS ON MAGNETIZED BODIES.

About four years ago Mr. William Marconi announced the invention of a new type of indicator for electrical oscillations. It had been found that the oscillating currents set up by the electrical waves produced a decrease in the magnetization of a magnetized piece of iron, and this decrease in magnetization could be utilized by means of a secondary current thereby set up to detect the waves. In other words, it offered a method of constructing a wireless telegraph receiver. The explanation of this action which is usually given is that the oscillations affect the iron in much the same way as any vibration; that they annul or decrease the hysteresis effect and allow the iron to approach a condition more nearly normal or that in which there will be no hysteresis loss. This matter has been investigated by Dr. W. H. Eccles, who discusses it in a recent paper before the Physical Society, of London, and who comes to the interesting conclusion that this explanation is incorrect.

The means of carrying out the work consists in brief in magnetizing two similar bundles of iron wire by two similar magnetizing coils, both coils being connected in series and both coils and bundles being placed so that each neutralizes the effect of the other on a magnetometer interposed between them. Around one of these bundles of wire was placed the coil through which the electrical oscillations were sent. The method of experimenting consisted in carrying the bundles of wire through magnetic cycles until a stable condition was reached. Then an oscillation was set up in the special coil, and the effect upon the magnetization of the iron was noticed by reading the change in the magnetometer deflection. The latter instrument was set up so as to be exceedingly sensitive. Readings were taken for various points on hysteresis loops corresponding to various maximum intensities of magnetization. The oscillation was provided by the discharge of a static machine, and it made no difference which pole of this machine was connected to the oscillation coil. It was found that, under similar conditions, similar deflections of the magnetometer could be secured, thus indicating a satisfactory arrangement of the apparatus; and that the effect of the oscillation varied according to the degree of magnetization, it being a maximum when the magnetic condition of the iron was that represented by the point of inflection of the hysteresis curve.

But the most interesting result of the investigation was that the oscillation has the same effect whether on the up or down side of the hysteresis loop—that is to say, in both cases the magnetization of the iron was decreased, while, as is well known, jarring the iron on the up curve would increase its magnetization. The oscillation, therefore, would seem to have an action different from the annulling of hysteresis. What it is is not known, though the author suggests that there may be intrinsic forces in the magnetized material tending to drag it into a more stable condition, which is not that defined as the normal curve of magnetization. He believes that the oscillations actually do work on the iron, thus being absorbed in hysteresis losses, and hints at certain other results which support this conclusion, but does not give them. The experiment, however, is exceedingly interesting, as it shows that in one case the oscillating current produces an effect in the same direction as the magnetizing force; while, in the other, it is opposed to it.

THE ELECTRIC ARC DESTRUCTIVELY APPLIED.

The use of the electric arc for constructive purposes, as in welding, tempering and other such uses, is more or less familiar. It has been adopted in a large number of industries. The use in the opposite sense, for destructive purposes, is new, and the suggestion made by Mr. R. A. Frickey in a recent issue of the Journal of Electricity, Power and Gas is interesting because it involves this idea. Some time ago an experiment was made with the electric arc for cutting metals, but nothing has since been heard of this plan, probably because it was found expensive as compared with mechanical cutting and because of the character of the surface left by the arc.

But these factors are minor ones in the application as proposed by Mr. Frickey, which is the use of the arc for clearing away the tangled mass of steel in the building ruins of San Francisco. This city, fortunately, is amply supplied with electric power, and in its rebuilding time-saving devices will be of the greatest value. But, preparatory to erecting new buildings, the ruins of the old must be cleared away, and the task of slowly sawing by hand one’s way through a distorted tangle of steel beams must be discouraging and irritatingly slow. To get around this trouble it is suggested that the electric arc be employed for cutting up the metal, and with this idea in view Mr. Frickey has made a number of experiments to determine the rate at which beams might be cut up. He found that in fifteen or twenty minutes he could cut through a large I-beam, which if sawed by hand, would require several hours. Moreover, since the arc can be applied in any direction, beams may be cut by means of it which it would be very difficult to get at in the ordinary way. Since the character of the cut made is of no importance, and the cost of the operation is of small moment compared with its rapidity, the suggestion is well worthy of an extended trial.
ELECTRICAL REVIEW

THE ROTATING MAGNETIC FIELD.

BY R. E. HELLMUND.

The nature of the rotating magnetic field, its distribution over the pole faces, its speed of rotation, etc., have been matters of discussion since its discovery by Ferraris. All publications known to the writer, however, although in many cases extremely valuable, are incorrect or misleading in some way or other.

He has, therefore, endeavored to give in the following a correct discussion of these phenomena.

In considering the rotating field, it is necessary to make a sharp distinction between the time distribution of the various fields and the space distribution of the field over the pole faces of the motor or apparatus. If we consider the flux passing through any part of the motor as a function of time, we deal with the "time distribution of the flux." If we consider, however, the densities on different parts of the pole face at a certain moment, we deal with the space distribution of the field over the pole faces. Most authors in determining the space distribution over the pole faces assume sinusoidal currents to flow in the primary windings, and then figure the resulting magnetizing effect of all the windings upon a certain part of the pole. They find therefrom the flux densities at various parts of the pole face. After having determined the space distribution and the total value of the flux for different instants of time, and from these the average value of the magnetic field, they assume this average field to rotate with uniform speed and thus determine the electromotive forces induced thereby in the conductors of the machine.

This way of proceeding is objectionable for various reasons. First of all, it is not logical to start from the currents flowing, because in practice not the currents but the impressed electromotive forces are given, and the currents flowing are, in their value and character, only a consequence thereof. Moreover, the above method gives incorrect results for the induced electromotive forces, since, as will be shown later on, the magnetic field does not rotate with uniform speed.

In order to obtain a true and exact picture of the nature of the rotating field, it is logical and advisable to follow up all phenomena in such sequence as they follow in actual practice. As mentioned before, the impressed electromotive force of a motor is given, and therefore the natural way of proceeding in outlining the theory is as follows:

A state of equilibrium is possible only if the counter-electromotive force of the motor is equal and opposite in value to and of the same wave-shape as the impressed electromotive force. Therefore, the electromotive force to be induced in the motor follows directly from the impressed electromotive force. Since for inducing a certain electromotive force a certain field is necessary, the field, in intensity and character, may be derived from the counter-electromotive force to be induced and, finally, the current values which are necessary to induce the field may be found. This way of proceeding has been partly used of late in some publications. The greater number of them neglect, however, the very important effect which the currents flowing in the secondary circuits have upon the field distribution. A very valuable treatment of the phenomena has been given in the Sibley Journal of Mechanical Engineering, by A. S. McAllister, which calls attention to the influence of the secondary currents. The conclusions derived in this publication are, however, not quite exact.

In the following discussion, a three-phase motor, with one slot per pole per phase in both members, will be considered in detail.

In Fig. 1 the lines M, N represent the air-gap; A,, B,, and C,, are the three primary windings; A,, B,, and C,, are the secondary windings. If we consider the current in each slot to be concentrated into a mathematical point in the figure, and the air-gap to be perfectly uniform, we may assume, according to the laws of magnetic induction, that the flux density in the air-gap between two current points, no matter whether said current points are placed on the primary or secondary member, is uniform.

Let total flux between the current points 3 and 10 be \( u \), between 10 and 4 be \( v \), etc., as indicated in Fig. 1. Then it may be easily shown that the flux of equal areas, which are shifted 180 degrees from each other, must be equal and opposite in value, and are so assumed in the following equations may now be written (see Fig. 1):

\[
\begin{align*}
 u + v &= a; \quad w + z &= b; \quad y + Z &= c. \\
 Z + u &= g; \quad v + w &= h; \quad z + y &= k.
\end{align*}
\]

If potentials of sinusoidal wave shape and 120 degrees phase displacement are impressed upon the primary coils \( A, B, \) and \( C \), the counter-electromotive forces induced in these coils must be also sinusoidal and of 120 degrees phase displacement.

Let the induced potentials be:

- in \( A \), \( E_1 = \sin a \)
- in \( B \), \( E_2 = \sin (a + 120) \)
- in \( C \), \( E_3 = \sin (a + 240) \)

where \( a \) is a function of the time.

From these it follows at once that the...
flucts surrounded by each primary coil must be:

for coil A, \( \phi_1 = \frac{dE}{da} = \cos a \)

for coil B, \( \phi_1 = \frac{dE}{da} = \cos (a + 120) \)

for coil C, \( \phi_1 = \frac{dE}{da} = \cos (a + 240) \)

From the figure it follows:

\[ \phi = a + b + c = \cos a \]

\[ \phi = e - a - b = \cos (a + 120) \]

\[ \phi = b - e + a = \cos (a + 240) \]

Solving, we have:

\[ a = \cos a + \cos (a + 120) \]

\[ b = \cos (a + 120) - \cos (a + 240) \]

\[ c = \cos a + \cos (a + 120) \]

These equations must be true no matter whether there are currents flowing in the secondary or not.

Consider first the condition with the secondary circuits open. No currents are flowing in the secondary, and the current points 5, 8, 9, 10, 11 and 12 may be considered as not existing. Then the flux at a is uniformly distributed between the points 3 and 4, the flux b is uniformly distributed between the points 4 and 5, etc. Therefore the density per space degree will be—

between 3 and 4 \( D_a = \frac{1}{60} \frac{\cos a}{\cos (a + 240)} \)

between 4 and 5 \( D_a = \frac{1}{60} \frac{\cos a}{\cos (a + 120)} \)

between 5 and 6 \( D_a = \frac{1}{60} \frac{\cos a}{\cos (a + 120)} \)

From these equations we may find the space distribution of the field for different values of a as shown in Figs. 2—8. We also may easily find the values of the total flux \( \phi \) for different values of a.

As will be seen from the figures, the field moves along the air-gap in the indicated direction, but its space distribution is not sinusoidal. The fact that the induced counter-electromotive force in the primary coils must, in spite of this, be sinusoidal, as shown in the previous considerations, is due to three phenomena which combine with the rotation of the field.

1. The resultant field does not rotate with uniform speed. If we consider as centre line of the field that line which has an equal number of lines at each side, we find that its distance H from the current point 3 is as given in the figures. As will be seen, the centre line travels from the position in Fig. 2 to that in Fig. 5, thirty space degrees, during thirty time degrees, but the speed of the centre during this time interval is not uniform. The average speed during the time interval \( a = 0 \) to \( a = 10 \) is \( a = 90 - 80.5 = 9.5 \). during the time interval \( a = 10 \) to \( a = 20 \), we have \( a = 80.5 - 70.5 = 10 \) and during the time interval \( a = 20 \) to \( a = 30 \), we have \( a = 70.5 - 60 = 10.5 \). This proves the statement made above that the speed of the field centre varies during the time interval thirty degrees.

2. The various parts of the field travel at different speeds. While in Fig. 2 the total field is distributed over three teeth, in Fig. 5 it is distributed only over two teeth, showing that although the centre of the field has travelled through thirty space degrees during thirty time degrees while changing from Fig. 2 to Fig. 5, the portion of the flux ahead of the centre must have travelled with an average speed greater than that of the centre. If, however, we compare Figs. 2 and 8, we see that the fields of these two figures are equal in all parts but are shifted sixty space degrees. This means that the speeds of the various portions of the field differ from each other and vary during a time interval of sixty degrees.

3. The total number of magnetic lines varies during the time interval of sixty degrees. As will be seen, the total field is two in Fig. 2, 1.97 in Fig. 3, 1.88 in Fig. 4, etc., and is again two in Fig. 8.

The average value of the total number of lines is 1.905. If a sinusoidal field of a strength equal to this field is assumed to rotate with uniform speed, the induced electromotive force would be proportional to 1.905 = .9525, while in reality, as follows from the previous considerations, the electromotive force is proportional to 1.905 = .9525, which is 5 per cent larger. It is, therefore, not permissible to assume a sinusoidal field equal to the average value of the true field.

In the case under consideration, for instance, if an equivalent sinusoidal field of uniform speed be introduced for the actual field, its strength must be assumed equal to the maximum value, which the field assumes in Figs. 2 and 8.

If, therefore, we consider any problem involving the theory of a rotating field and an open secondary, we must bear in mind the following facts:

(a) A field of irregular space distribution rotates.

(b) The space distribution of this field is determined by the distribution of the windings, the character of the pole-pieces and the wave-shape of the impressed electromotive force.

(c) If sinusoidal electromotive forces are impressed, and a uniform air-gap be assumed, the centre of the field travels with a periodically changing speed; the various portions of the field travel with speeds which are different from each other and change also periodically with the time, and the total strength of the field changes periodically with the time.

(d) The resulting effect of the rotation of the irregular field and the phenomena under (c) is that sinusoidal electromotive forces are induced in the primary windings.

(e) Therefore, it is for certain studies permissible to assume a sinusoidal space distribution of the field and a constant speed of rotation.

(f) The strength of this imaginary sinusoidal field may be determined for full pitch windings from the maximum number of lines which must pass through a certain coil in order to induce the necessary counter-electromotive force. If coils which are shifted in space with respect to each other are connected in series, this phase displacement must, of course, be taken into account when determining the electromotive force of the single coil.

The determination of the currents which are necessary to flow in order to induce a field of the previously described character is very simple in our case. A glance at Fig. 1 shows that the flux b is induced by coil A1 only. If the magnetic reluctance of the flux be assumed to be constant, the current in A1 must therefore be proportional to the flux b. We find, therefore—

\[ I_{A1} = b = \cos a \]

and similarly—

\[ I_{A3} = \cos (a + 120) \]

\[ I_{A5} = \cos (a + 240) \]

In practice, the reluctances of the motor are not quite constant, and therefore the current waves are not quite sinusoidal, but somewhat more pointed.

Consider now the phenomena of the rotating field with closed secondary circuits. If a field of constant strength and distribution rotate with uniform speed, and the secondary circuit rotate in synchronism with the field, there would be no electromotive force induced in the secondary circuits and no currents would flow in them. In this case the secondary circuits would, of course, have no influence whatever upon the field.

We have seen, however, that the field induced by the primary member rotates with irregular speed and varies also in strength. If, therefore, the secondary
circuit rotates with uniform speed equal to the average speed of the field, there will necessarily be electromotive forces induced in the secondary circuits on account of the varying field speed and the varying field strength, these electromotive forces being dependent upon the difference between the uniform secondary speed and the speed of the field, and upon the rate of change of the field strength. These electromotive forces will, of course, set up currents in the secondary circuit as soon as the latter are closed, and these currents will have a magnetizing effect upon the field, which combines with the magnetizing effect of the primary.

Now we know that the currents in any short-circuited winding having no ohmic resistance will always adjust themselves so that the field passing through the winding will be kept constant. Since the secondary resistance of induction motors is always very low, we may assume that the fields passing through any of the secondary windings will be constant. If this be true, it may easily be shown that the total field of each secondary tooth must be also constant in the case under consideration. We know, therefore, that in our particular case the fluxes $g, h$ and $k$ must be constant values. We know, moreover, from our previous considerations the values which the fluxes $a, b$ and $c$ must assume in order to induce a sinusoidal electromotive force. Since, moreover, we assumed in our case an equal number of slots for the primary and secondary members, we know that there must be, if the secondary rotate, a time point $t$ at which points 3 and 9 and 4 and 10 coincide respectively. At this instant the flux $g$ must be equal to the flux $a$ and we have

$$g = a = \cos a + \cos (a + 240),$$

and since $g$ is constant, $\cos a + \cos (a + 240)$ is its constant value. Similarly, the constant values for $h$ and $k$ may be found to be:

$$h = b = \cos a$$
$$k = c = \cos a + \cos (a + 120)$$

From Fig. 1 follows:

$$g = u - z$$
$$a = u + v$$
$$h = v + w$$
$$b = w + x$$
$$k = z + y$$
$$c = y + z$$

From these equations we find:

$$u = 1/2 (a + b + c + g)$$
$$v = 1/2 (h + b - c - a - g)$$
$$w = 1/2 (b - k + c + h - a + g)$$
$$x = 1/2 (c - g - a + h + b + k)$$
$$y = 1/2 (g + a - h + b - k + c)$$

angle between two stator current points or two rotor current points is always sixty degrees. If, therefore, we know the angle $\beta$ between 9 and 3, we also know the angle between 3 and 10 to be $60 - \beta$ (see Fig. 1).

If we consider now the angle of two pole faces respectively of one pole pair to be 360 degrees, and assume the rotor to rotate with synchronous speed, we know that the time angle $\beta$ is necessary to move the rotating member by the angle $\beta$ forward. If now, as assumed before, the primary and secondary current points coincide at the time $t$, i.e., if the angle $\beta = 0$ at the time point $t$, the angle $\beta$ will be at any other time, $a$, as follows:

$$a = -t = \beta$$

because we must have at the time $a = t$

$$t - t = \beta = 0$$

We see now, from Fig. 1, that the densities per degree are as shown below:

$$D_a = 1/\beta$$
$$D_v = 1/\beta$$

The value of $t$ is more or less a matter of chance, and may be anything. Therefore the densities $D_a, D_v$, etc., may assume a great many values.

For a certain value of $t$, however, the densities, and therefore the character of the rotating field, are positively determined.

In Figs. 9 to 15 the field distribution is given for $t = 0$, and $a = 0$ to $a = 60^\circ$. As will be seen, the field distribution is, with closed secondary, totally different from the field distribution with open secondary, as shown in Figs. 2 to 8; with the exception of Figs. 2 and 9 and 8 and 15, which are equal respectively.

As will be noticed, the field for the closed secondary case is still irregular and has a step form. It may also be shown that the speed of the middle line of the field, as well as the speed of the different parts, is, as before, not uniform. It will be seen, however, that for those values of $a$ for which the secondary reaction has changed the field, the new field shape is much more of an approach to the sine wave, which is shown in dotted lines in some of the figures for comparison, than it was when associated with an open secondary.

It will be also noticed that the total field is now, for all values, equal to the equivalent sine field, and the maximum densities come much nearer to the maximum densities reached by the sine field.

These latter facts will also be noticed if the field distribution is determined for other values of $t$. For each value of $t$, however, there will be some values of $a$ for which the primary and secondary current points coincide, and for these values the field distribution will not be changed, at least not in the case under consideration, by the secondary reaction. If we assume, for instance, $t = -30$, we find
for \( a = 0 \) the field distribution shown in Fig. 16, and that for \( a = 30 \) in Fig. 17. This last figure shows that there are also, with the closed secondary, cases possible in which the total field is smaller than the equivalent sine field, and in which the maximum density is considerably smaller than that of the equivalent sine field.

We may conclude, therefore, that with a closed secondary, the rotating field changes also in value and speed as brought out in detail for the motor with an open secondary, but the secondary reaction strongly tends to change the field into a sinusoidal field of uniform strength and uniform speed. In motors with more than one slot per pole per phase, the changing of the field on account of the secondary reaction toward a sinusoidal field is much more emphasized than in the case under consideration, and therefore we may, in practice, almost in all cases start with the assumption of a sinusoidal field of uniform strength and speed, although it is, for the explanation of some phenomena, necessary to consider the actual facts, as has been done above.

**New Lamps and New Opportunities.**

F. W. Willcox, in his paper on “New Lamps and New Opportunities,” read before the Put-in-Bay convention of the Ohio Electric Light Association, strongly endorses active work by the central stations in pushing the newer units. He refers to the policy that the gas companies maintained for a long period in reluctantly putting out the Welsbach mantles, which have now become their only salvation. After speaking generally of the advantages of a liberal attitude on the part of public service companies to patrons, he proceeds to outline a method by which to introduce the new high-efficiency lamps, in the course of which he incidentally refers to the new system of ratings as superior to the old method in use, as allowing even-watt ratings instead of fractional ones, and as ensuring a more uniform appearance and a more uniform performance of individual lamps by reason of the even degree of incandescence or efficiency at which a filament so rated will burn. It also permits central stations to gradually advance their standard of efficiency from time to time to meet changing conditions. Attention is called to the voltage markings arranged in a vertical column in steps of two volts apart. These voltages are known as the “top,” “middle” and “bottom,” or first, second and third voltages. Central stations now using 3.1-watts-per-candle lamps would naturally adopt the new lamps at full efficiency (top voltage) and thus keep their watt consumption per lamp unchanged. While the total cost of lamp renewals would be increased somewhat on this basis, the added charge is a small one to pay for the ability to give consumers twenty-five per cent more light for the same revenue. Central stations now using 3.5 watts-per-candle lamps could optimally adopt the new lamp in the middle or second voltage. This would share the improvement with the consumer, giving twelve per cent more light with fifteen per cent less wattage. The total cost of lamp renewals, which are very low for the present 3.5-watts-per-candle lamps—only about one-third cent per kilowatt-hour, would be only slightly increased, and there is hardly any lighting company that could not profitably afford to make the change to at least this intermediate efficiency of the new lamps. Its useful life, 750 hours (with average life materially longer), is commercially sufficient, as it is equal to that formerly given by 3.5-watts-per-candle lamps. The life of 3.5-watts-per-candle lamps is at present too long for the most economic service and could with advantage be shortened to correspond with that given by the new Gem lamp in middle voltage. The writer advocates the policy of free lamp renewals as desirable, and in this connection refers to the 1906 National Electric Light Association Question Box on this point, pages 250 to 250. The answers to a number of questions on lamp supply and renewal policy show overwhelming testimony in favor of free and liberal renewals. Indeed, says the writer, practice goes much further, in many instances giving free signs to burn the lamps in; a policy which experience has shown pays handsomely. With the advent of the new Gem lamp the importance of central station direction and control of lamps is greater than ever. Full and complete control is only obtained with free renewals, and the adoption of a free-renewal policy where not already in vogue could therefore most opportunely be made with the introduction of the new Gem lamp. Companies now giving free renewals should do likewise with the new lamp; and those now charging for lamps should supply this new lamp without any increase of price. Unless the policy for the new lamp be at least as liberal as that for the present lamps, the introduction and general use of the new lamps is apt to be retarded. The writer gives interesting data in tabulated form with reference to the tantalum lamp units in comparison with the ordinary carbon filament and the Gem, and touches on reflectors, with special reference to the new bowl holophanes. In conclusion, the writer says that the liberal policy he recommends embraces the following points:

1. To secure free renewals and promote a more liberal use of lamps.
2. To furnish suitable and efficiently designed reflectors to consumers on as liberal terms as possible.
3. To undertake illuminating engineering work on all lighting installations both old and new, to the end of aiding consumers to secure the most efficient illuminations.
4. To eliminate as far as possible all the worthless reflectors and replace them with efficient types, and to generally improve conditions of lighting service in every way possible.

Since the introduction of the Welsbach lamp there has been quite an overhauling of lamps, fixtures and shades for gas lamps to the great improvement of gas lighting service, and large amounts of money have been spent by consumers for the new devices. Electric lighting installations must undergo a similar overhauling to improve lighting results and enable the electric light to withstand the improved conditions of gas competition. The introduction of higher-efficiency incandescent lamps is the logical time to make this overhauling and to induce customers to discard their old lamps and fixtures for new ones, to also displace their old reflectors with new and improved ones. What has been done and is being done in the gas way can be done in the electric business if only central station companies will see the handwriting on the wall, and reap the full advantages of the new lamps and the new opportunities.
The Truckee River General Electric Company.

The Truckee River General Electric Company was organized in the fall of 1899, for the purpose of supplying power to the famous Comstock mines, at Virginia City, Nev. These mines had long been partially idle, due to the inability to successfully handle the water in the lower levels, and the working out of the upper levels. The electric power was expected to make the draining of the lower levels possible, as well as to cheapen operation in every way, as steam power was very expensive. The company was organized with Mortimer Fleishhacker as president and Herbert Fleishhacker secretary, with the firm of Hunt, Merideth & Cory, consulting and constructing engineers.

The original plant was constructed at Floriston, Cal., on the Truckee river, thirty-three miles from Virginia City.

The dam is constructed of twelve by twelve-inch timbers, drift bolted together, filled with rocks, and sheeted with double two-inch planking, the headgates and bulkheads being of similar construction.

The flume, about two miles in length; is built entirely of mountain pine, and was originally ten feet by six feet six inches. It has since been raised to eight feet six inches in depth. It has a grade of six inches per 1,000 feet, and carries about 300 cubic feet per second. Considerable trouble was experienced with ice in this flume, and various screens and methods were tried, to overcome it. The present method has been in use about three years, and has proven very satisfactory. The screen is made of flat iron, one and one-quarter inches by one-quarter inch spaced one inch apart, and is made in sections, hinged at the upper end, and with a chain on the lower end so that it may be raised. This screen is placed diagonally in the flume, the flume having been widened for this purpose. It is placed directly at the penstock, and the entire screen and penstock is housed in, so that it is protected from storms, and so that men can work in the coldest weather.

A steam boiler is also installed, and steam jets used, to keep the gates and screen from freezing solid. During very cold weather the screens are raised, allowing the water to flow under them, while the screens and a boom keep out all surface ice, which passes over a spillway.

From the penstock, two six-foot wood stave-pipes lead to the power-house, where a head of eighty-five feet is obtained. The wheels are governed by Lombard type "B" governors. Some trouble was first experienced with these, owing to the oil used, which rusted all the steel and iron parts, and also due to oil pumps. With the oil now furnished with these governors, and the improved pumps, they
have given excellent satisfaction. The wheels were originally installed with an eighteen-inch relief valve, which was connected with the gate rigging, so that it rapidly cut and wore loose and have been replaced with solid bronze runners, which have worn very well.

Two Westinghouse twenty-two and one-half-kilowatt exciters were originally direct-connected to McCormick horizontal turbines, but owing to the exceedingly small openings between the guide vanes, they easily clogged, especially with ice. One of these units was therefore belted to an induction motor, and the induction motor belted to a Risdon water wheel, the belting being necessary to get proper speed. This set is entirely self-governing, and the only difficulty found was under a very heavy short-circuit, when plant was slowed down, the belts would be thrown off. An overload and underload circuit-breaker, installed in the induction-motor circuit, overcame this by cutting out the motor and allowing the water wheel to carry the exciter alone for the time.

An electric signaling apparatus shows the height of the water in the penstock and at the head of the flume. That at the head of the flume is merely a resistance that is cut in and out by a float, and which varies the current through an ammeter on the switchboard. That in the penstock is a number of colored lights, placed on top of the switchboard, which light and extinguish one after the other.

The generators deliver current at 500 volts to two sets of 300-kilowatt Westinghouse air-cooled transformers, which step the voltage up to 22,000 for the line. The transformers are delta connected on low-tension, and star connected with neutral grounded, on the high-tension side. The high-tension side passes through two sets of D. T. Masson Taylor switches which are only used for changing circuits, however, and never opened under load. From the power-house a single-pole line is run to Virginia City, thirty-three miles distant, carrying two circuits of No. 4 bare copper wire, strung on Locke seven-inch glass insulators. A line also extends two miles to the Floriston Pulp and Paper Company. A branch line leaves the main line about half way to Virginia City, and delivers power, a distance of six miles, to Reno.

The plant has been in operation for five years, and during the past two years has been delivering its full capacity of about 2,200 horse-power almost continuously, one machine being shut down every Sunday for cleaning and repairs.

The success met with on the Comstock under the direction of Leon M. Hall, in both handling water on the lower levels, and in hoisting and general work, decided the mines there to install further pumping plants. Mr. Hall has accordingly designed a plant, consisting of duplicate units, handled by two 800-horsepower induction motors. To supply the power for these, and also for the constantly increasing general business, the Truckee river company decided to install an additional plant. The Fleish plant is located on the Truckee river, five miles nearer Virginia City than the old...
plant. The water is diverted by a rock-filled crib dam, and carried through 9,000 feet of flume and 3,000 feet of ditch, to a point where 125 feet head is obtained. The flume is ten feet by six feet six inches inside, has a grade of six inches per 1,000 feet, and is designed to carry about 275 cubic feet per second. The planking is tongue and grooved Oregon pine, surfaced, which leaves a very smooth interior. The ditch is twelve feet wide on the bottom, sides slope one to one, and will carry six feet of water with the grade same as flume. The flume timbers are of mountain pine, bents eight feet apart, with four posts ten by ten inches, four stringers eight by fourteen inches, yokes two feet eight-inch centres, of six by eight inch.

The wheel is fitted with two Lombard relief valves, and controlled by a Lombard type “N” governor. Only one exciter is being installed at present, it being belted to generator, while provision for another, with independent drive, is being made.

The switchboard contains a Tirrill regulator, main switch, exciter switch, one ammeter, one voltmeter, one power-factor meter, one frequency meter, one synchroscope, one General Electric curve-drawing wattmeter, and rheostats. One marble panel also contains all lighting and signaling circuits. Two water signals, one will be operated by twelve-inch copper hall floats and bicycle wheels. The power-house is of granite, and all wiring is carried in tiling under the floor, and to a separate stone transformer house, where four 750-kilowatt transformers and Westinghouse lightning arresters are placed. Immediately outside the transformer house are located nine three-pole, 23,000-volt, air-break, horn-type switches. Through these switches pass the two old lines and the new line, so that any combination of lines and generators can be handled. A second pole line is constructed to Virginia City, using thirty-five feet, eight-inch top, cedar poles, spaced 200 feet regularly, with long spans and double construction over canyons, with one circuit of No. 00 stranded aluminum, six-foot centres, carried on one and three-quarter-inch pins and Locke seven-inch glass insulators.

The lines leading from the Truckee River Company's plants consist of two high-tension three-phase copper lines, carried on the same pole, from Farad to Virginia City, with a branch leading to Reno and Sparks, Nev. At Fleish, Nev., a third line of aluminum wire joins the two mentioned above and parallels it to Virginia City. Sets of nine high-tension switches are located at both Farad and Virginia City, making it possible to run with almost any imaginable combination. This arrangement makes a shutdown from failure of the lines almost an impossibility, as it is hardly likely that all three lines will fail at the same time. From the main Farad-Fleish-Virginia City line a number of single branch lines are run to supply the neighboring towns, mines and larger ranches. The copper lines are of No. 4 wire, the six wires being arranged in the form of two thirty-six-
inch equilateral triangles, one on each side of the pole. The pins are of eucalyptus wood boiled in oil, upon which are mounted seven-inch Locke glass insulators. Spans are about 125 feet. The aluminum line is of No. 00 seven-strand wire supported on pins and insulators of the same character as in the copper lines. The cross-arms are of five-inch by six-inch Oregon pine. The insulators are spaced to form a six-foot equilateral triangle. Where the pole line is straight, the top pin is put into a hole bored in the top of the thirty-five-foot cedar poles. This is prevented from cracking by eight or ten turns of No. 10 iron wire securely stapled in place. The poles on this line were spaced with the intention of making them 200 feet apart but on account of the rough condition of the country it was impossible to follow this plan throughout. There are about twelve spans over 400 feet long, and two of these are respectively 986 and 1,105 feet in length. The method of bracing and supporting is shown in the accompanying illustrations.

The largest single substation on the circuit is located at Virginia City. This station has four 625-kilowatt and six 250-kilowatt transformers, all stepping the voltage down from 22,000 volts to 2,200 volts. The 625-kilowatt transformers are of the standard water-cooled type, as manufactured by the Westinghouse Electric and Manufacturing Company. The 250-kilowatt transformers were originally of the simple oil type, but water coils for cooling have been added to increase the capacity. The transformers are all connected through quick-acting valves to the large steel oil-tanks located outside the building, in order that they may be emptied almost instantly in case of necessity. The substation building is of brick with a galvanized-iron roof. A photograph of the switchboard is shown herewith. It has two sets of bus-bars, so that the load can be operated separately, a very important feature on account of the character of the load. The switchboard contains the usual complement of voltmeters, ammeters and wattmeters, also a synchroscope and frequency and power-factor meters. There are two integrating wattmeters, either of which is capable of measuring the entire output of the station. The individual circuits are so arranged that wattmeters can be put on at any time this may be desired, space being left over each automatic oil break switch controlling the different circuits, so that a panel can be readily mounted.

There are two substations in the city of Reno. The first was built by the old Truckee River General Electric Company, and the second was acquired by the Reno Light and Power Company upon its consolidation with the Washoe Power Company. The original station is a brick building containing four 200-kilowatt Stanley water-cooled transformers connected to convert 22,000-volt, three-phase current into 2,200-volt, two-phase current. The lightning arresters and switch-
Electric Motors in Competition with Gas Engines.

Some interesting features of electric motor service in competition with gas engines are pointed out in the paper read by Mr. Wm. Wolls before the Ohio Electric Light Association, at Put-in-Bay, August 22.

In the case of the individual drive, machines can be located irrespective of any main line shaft; the use of quarter turn belts or angle drive where they would otherwise be required is eliminated and friction losses reduced thus to a minimum. Another advantage is found in the fact that whereas with a single prime mover with one main shaft, it is difficult to move machines any great distance from the main shaft, in the case of the individual motor the machines can be located any place and in any position where there is room regardless of the position of the prime mover and shafting; so that after a shop has been planned and machinery installed, if changes are found desirable they can be readily made with electric motors. The adaptation of electric motors to pumping plants is spoken of, and the writer states that during the past year he has displaced a number of gas engines by direct-connected motor-driven outfits. The advantages are reliability of service, automatic control, and maintenance of the water level in a compression or open tank; attendance merely nominal, whereas with the gas engine it is necessary to fill oil cups and note condition of the water jacketing guarding against freezing during the winter and the general operation of the unit. In the failure to start much valuable time is often wasted. Another point that has been worked out in the vicinity of the writer's plant is the feature of fire protection; the pump discharge is so arranged that it is possible to cut out the tank under fire conditions and pump direct to the fire main. An instance is given of the variation in angular velocity which unites the gas engine for use where constant torque or pull is desired, and causing an effect very telling on the upkeep of the shop equipment of shafting, hangers, belts and the alignment of same. There are also many conditions where the application of gas engines could not be considered, such, for example, as the driving of a large newspaper printing press. The cost of power should not be the sole determining factor in the choice of the motive power. A comparison as to the first cost, weight, floor space occupied, cleanliness, noiselessness, ease of manipulation, freedom from repairs and reliability of operation shows every point to be in favor of the electric motor. Furthermore, the gas engine has no overload capacity, and consequently it is necessary to install an engine to meet maximum demands, which, in many cases, will be entirely too large for average operating conditions, seriously affecting the efficiency at such load. It is also necessary to put in a heavy foundation to mount the gas engine upon, while the motor is usually placed upon the floor or mounted out of the way on the side wall or ceiling. The gas engine is not self-starting; hence a loose pulley or clutch device must be used to enable the machine to reach full speed before taking the load. The increased first cost of the gas engine over an electric motor of same horse-power must be added to the heavy annual cost of repairs and depreciation, which will materially discount the claim of low fuel consumption by the gas engine; even more important is the loss of time due to frequent and annoying shut-downs as the efficiency of a shop or factory depends upon continuity of operation. There is no doubt that the gas engine is well capable of maintaining its position. It is, of course, necessary that the solicitor of power business be a person who can make his own choice, even if the saving is not apparent. It is also necessary that the solicitor of power business have an engineer's training, as each prospective installation calls for most careful consideration of details, it being seldom that the conditions in any two plants will be precisely similar. It is usually upon the judgment of the solicitor that the success of the installation to the satisfaction of the customer depends.

Power-House of the Washoe Power and Development Company.
FUEL, WATER AND GAS ANALYSIS FOR STEAM USERS.

II.—THE APPROXIMATE ANALYSIS OF FUEL.

PREPARING THE SAMPLE.

The sample of fuel after the operation of sampling as described in Article i should amount to about one pound, with no particles that exceed one-quarter inch in diameter. The sample should now be passed through a brass wire sieve (A), Fig. 2, of one-twelfth-inch mesh, and the portion which will not pass through should be finely crushed by grinding in a No. 3 Kenrick coffee mill. Fig. 2 B shows a small mill, adapted for the preparation of laboratory samples of fuel. If the fuel be very wet, or if the sample contain any very hard lumps of shale, this method of preparing the sample requires modification.

The excessive moisture can be removed by spreading out the whole of the fuel sample on a piece of paper, and by leaving it exposed to the air for two or three hours in a warm place in the laboratory before sieving and grinding. The difficulty caused by lumps of very hard shale can be dealt with by picking these out of the sample and by crushing them separately in the steel mortar C shown in Fig. 2. Care must be taken that none of the shale is lost in this operation, for shale possesses little heating value, and the proportion of it in a sample of fuel has great influence upon the tests for ash and calorific value. Shale and dirt are, in fact, the chief causes of the difference in value of bituminous fuels, and when the thermal results are worked out upon pure coal or combustible matter only, the variations are small and are chiefly those due to differences in the chemical constitution of the coal. For this reason, it is wise to cover the mortar and the coffee mill with a card or towel when crushing shale, since bits have a decided tendency to jump out and to get lost during this operation. After crushing in the mortar, the whole of the shale must be passed through the coffee mill, and the ground material returned to the general mass of the sample, which will now occupy double the former volume, and resemble in appearance a heap of coarse gunpowder.

The sample is then reduced by repeated mixing and quartering; as described in Article i, until only about 100 grammes (one-quarter pound) remain. This is divided into two equal portions, one of these being used for the following tests, and the other being reserved in a stoppered bottle for use in case of any mishap in carrying out the tests with the first portion.

The remaining portions of the sample are likewise not thrown away, but are retained in the one-pound tin, in case of accident or dispute. Each sample tin should bear a label giving full particulars of the date of sampling, the origin of the fuel, and any other information regarding it that may be necessary for proper identification of the sample and test. In cases where a large number of samples are being dealt with at one and the same time, considerable care is necessary to prevent confusion of the samples; and the use of written labels is all the more urgent. For testing purposes the samples may be simply marked A, B, C, etc., if the original sample tins bear corresponding letters, in addition to the full details of the fuel and date of sampling.

TESTING THE FUEL.

The approximate analysis of fuel covers the estimation of the following constituents: 1—Moisture, 2—Ash, 3—Volatile Matter, 4—Coke, 5—Fixed Carbon and 6—Sulphur. These will now be dealt with in the order named.

1—Moisture—Ten grammes of the fuel sample, prepared as already directed, are weighed out upon a chemical balance reading to one milligramme, and are heated for two hours at 230 degrees Fahrenheit (110 degrees Centigrade), in a copper or aluminum air-bath. The loss of weight multiplied by ten gives the percentage of moisture in the original sample. A desiccator must be employed for cooling the sample before weighing, as perfectly dry fuel absorbs moisture from the air and gains in weight, even while being weighed on the balance. It saves time, however, if the crucible be allowed to go nearly cold in the air with the lid on, before being placed in the desiccator. On no account must the crucible be placed on the balance pan and weighed while still hot, as this will give increased weighings.

The crucible must be covered during heating in the air-bath and the lid removed only when weighing.

The balance shown in Fig. 3 is most suitable for fuel-testing work; it carries a load up to fifty grammes, and reads correctly to one milligramme. The weights should always be placed in the left-hand pan, the fuel in the right. The sample of fuel should not be weighed out directly upon the pan, but in a tared porcelain crucible. (A No. 1 Berlin crucible holds ten grammes of most fuels.) A lead counterpoise can be made from sheet lead with little trouble, and the operation of weighing out ten grammes of the fuel sample with this crucible is then very rapidly performed, since the lead counterpoise undergoes little change in weight; and only rarely requires fresh adjustment. The lead counterpoise should be bent into the form of the letter L, to facilitate removing on and off the pan of the balance. The second weighing of the fuel sample, after heating two hours at 330 degrees Fahrenheit, can be most quickly performed by placing the lead counterpoise and the ten-gramme weight on the left-hand pan of the balance, and by adding the fractional parts of one gramme to the right-hand pan in which the crucible is placed, until equilibrium is obtained. The final adjustment should always be made by means of the rider (the little platinum weight which rides across the beam and records decimal fractions of one centigramme) with the front of the balance.
The total of the weights placed in the right-hand pan to restore equilibrium after heating then represents directly the loss of moisture, and multiplied by ten gives the percentage of moisture in the original sample.

The air-bath most suitable for heating fuel is shown in Fig. 4. It is made of copper, and is provided with a thermometer reading up to 300 degrees Fahrenheit, and with an automatic gas regulator which keeps the temperature within five degrees Fahrenheit of that desired. That shown in Fig. 4 is the Reichardt Muencke type of regulator. The burner is a Bunsen gas burner with a rose top, and this must be placed quite close to the bottom of the oven. Unless a gas regulator be used, the air-bath requires constant attention, for the gas pressure varies greatly at different hours of the day.

The only precaution necessary with a gas regulator is to see that there is no danger of lighting back when the main gas current is entirely cut off and only the by-pass supply is in use.

A water-bath is less troublesome than an air-bath, but the temperature attained in these can not rise above 212 degrees Fahrenheit, and therefore they are of no use for determining the moisture in fuels, the last traces of which can only be got rid of by heating above 212 degrees Fahrenheit.

Should it be necessary to determine the total moisture in very wet fuels, or in the fuel as delivered, it is necessary to determine the loss which occurs during the grinding and sampling operation.

For this purpose, the whole of the sample contained in the sample tin is placed on a porous plate, and is weighed as accurately as possible on a pair of ordinary scales. The plate with its contents is then placed in the sun, or in a warm place on the boilers for two hours, and the fuel is twice turned over during this period. A second weighing of the plate is made when cold. The loss of weight during this preliminary drying is then worked out as a percentage on the original weight of fuel, and must be allowed for in the final calculation of the moisture, as ascertained by the second and more accurate drying operations.

The remaining tests are all carried out with the ten-gramme sample of fuel, after drying in the air-bath at 230 degrees Fahrenheit (110 degrees Centigrade). This sample must, however, be still further reduced in fineness before commencing these further tests. The sieve D and steel mortar and pestle C shown in Fig. 3 are employed for this work. The former is of very fine brass wire, one-sixtieth-inch mesh, equal to 3,600 holes to the square inch; the latter is of cast steel and is four inches in diameter. The whole of the ten-gramme sample must be passed through this sieve. It will be found that this is most quickly carried out by repeated sievings, and return of the larger particles to the mortar, free from the finer portion. With semi-anthracite and shaly fuels, this final grinding operation is troublesome, but it is essential that it be carried out carefully, and that the whole of the ten grammes be passed through the one-sixtieth-inch mesh sieve, if correct results are to be attained. The final particles of very hard coal or scale which resist crushing to the last, must on no account be rejected. As already stated in Article 1, correct sampling is the basis of correct testing, and it is too often slovenly and carelessly performed. If left to untrained persons, it is certain to be badly carried out, and the whole of the test results are then worthless.

The finely ground sample is now carefully mixed on a sheet of glazed paper and is then transferred to a No. 00 (two and three-quarter-inch diameter) porcelain basin, which is covered with a clock glass, and is placed in the air-bath for one hour's reheating at 350 degrees Fahrenheit.

This is necessary to remove the moisture taken up during the final grinding of the sample. The sample is now ready for the remaining tests, and must be transferred to a stopped glass weighing tube, or kept covered in the porcelain basin in the desicator. Should the test be delayed some hours, a reheating of the sample in the air-bath for one hour will be necessary.

2—Ash—Two grammes of the finely ground and perfectly dry sample are weighed out in the pan of the balance, and are transferred to a No. 00 size Berlin porcelain basin. This is placed upon an asbestos board having a hole cut in its centre for the reception of the basin (see Fig. 6), and is heated until all the carbonaceous matter of the fuel is volatilized or burnt. The heating of the basin is best carried out over a No. 1 Bunsen burner, the asbestos board being supported by a tripod stand tilted at an angle as shown in Fig. 7, so that the products of combustion may pass away behind, and a current of heated air flow over the fuel from the front.

Bituminous fuels require very gentle heating at first in order that the volatile matter may escape gradually without carrying off any particles of solid fuel, and that the residue may not bake itself into a very hard mass of coke. The fuel should be turned over repeatedly with a platinum wire or spatula, during this stage of the heating process, to facilitate the escape of the hydrocarbon gases, and to prevent sintering together of the mass. After the hydrocarbon gases have escaped, the heat of the flame can be gradually increased, until the bottom of the basin where the fuel rests is at a dull red heat. The fuel as the fixed carbon burns away gradually becomes lighter in color, but it is somewhat difficult to get rid of the last few per cent of carbon. In order to effect
this, the basin should be removed from the flame, allowed to cool on a piece of asbestos board, and the ash carefully crushed with a small agate or glass pestle. The ash adhering to this is then brushed back into the basin with a small camel's-hair brush, the fine carbon dust which collects around the edges of the basin is brushed down into the centre, and the whole is again raised to a red heat, commencing with a small flame to avoid cracking the porcelain basin.

The first heating of the fuel to remove the hydrocarbon gases and to burn off the greater part of the fixed carbon of the coke requires generally from thirty to sixty minutes; and a further ten to twenty minutes’ heating is required to remove the last traces of carbon.

From one and one-half to two hours are therefore required for carrying out the ash test, and any attempt to reduce this time with bituminous coal will produce incorrect results. The ash should be light in color and quite free from black specks, which denote unburned carbon. The basin, after removal from the flame, is allowed to nearly cool in the air, and is then placed in the desiccator and its contents weighed when cold. The ash is carefully brushed out of the basin on to the pan of the balance or on the copper foil for weighing, and the spatula or wire used for mixing the fuel must also be carefully brushed free from any particles of ash adhering to it. The weight of ash multiplied by 50 gives the percentage of ash in the dry fuel.

Ash which is red in color denotes the presence of iron impurities in the fuel, probably as “coal brasses” (pyrites).

The behavior of bituminous fuels on heating is quite different from that of semi-anthracite and anthracite fuels; and after a little experience in testing coals from various sources, much information can be obtained as to the character and quality of the fuel by careful observation during the ash test.

When a large number of ash tests have to be performed daily, it saves time to use a muffle heated to redness in a gas-muffle furnace, the fuel samples being contained in shallow trays made from platinum foil. These must be numbered from 1 to 6 or 12 by notches cut with scissors in their edges, and great care must be given to avoid confusion of the samples, and to the question of a proper current of air over the samples. If the heating be too rapid or if the draught be too great, some of the finer particles of fuel or ash may be carried away with the exit gases. For this reason, the porcelain basin method is the safest for ash determinations, especially for those non-conversant with muffle furnace management. The ash obtained from each fuel test should be placed in a small paper bag and kept in the tin with the original fuel sample, for reference in case of trouble with the fuel, or of dispute.

3, 4 and 5—Volatile Matter, Coke and Fixed Carbon—These three constituents of fuel are all determined by the one test, which consists in heating one gramme of the finely crushed and dry sample of fuel in a covered platinum crucible until all the hydrocarbon gases are expelled. The crucible and its contents are then again weighed. The loss in weight multiplied by 100 gives the percentage of volatile matter, and the weight of the residue multiplied by 100 gives the percentage of coke. On deducting the percentage of ash as ascertained in test No. 2 from the percentage of coke, one obtains the percentage of fixed carbon. Very careful manipulation is required in carrying out this test in order to obtain correct results, and the following conditions must be strictly adhered to. The apparatus is shown in Fig. 8. The platinum crucible should measure 1.40 by 1.10 inches diameter and should be provided with a very closely fitting lid. If the crucible has been bent out of shape, causing the lid to fit badly, it can be restored to its original circular form by rolling on a hard surface while hot, with pressure applied by a rounded stick or glass rod in its interior. The crucible and lid should be thoroughly cleaned after each test, by burning off the adhering graphite and soot, and by polishing inside and out with wet sand. The gray deposit formed by the burner flame on the bottom of the crucible (due to formation of a carbide of platinum) should also be removed by sand after each test, as a platinum crucible rapidly corrodes and deteriorates when dirty and dented.

A platinum wire triangle is made for holding this crucible, by twisting together three pieces of thin platinum wire, and by mounting these in the centre of an ordinary pipe-stem triangle, as shown in Fig. 8. No other method of supporting the crucible in the flame is admissible for coke tests, since it is absolutely essential that the crucible and its lid should be entirely surrounded by flame during the test. The Bunsen burner must be of No. 1 size, and should give a steady colorless flame at least seven inches high. The tripod stand should be eight inches in height, and must be so arranged that the bottom of the crucible when supported by the platinum wire triangle is not more...
than one and one-half inches from the top of the burner. If the place where the test is carried out is at all subject to side draughts, cardboard screens must be arranged round the tripod and burner, to prevent access of air to the crucible while the heating is in progress.

A lead counterpoise should be made for the crucible and its lid, to facilitate the weighing operation. This counterpoise will require adjustment at short intervals of time, since the platinum crucible will lose gradually in weight by the frequent cleanings. The one gramme of fuel must be very carefully weighed into the crucible, with a possible error of not more than one milligramme.

The crucible is then covered, inserted in the triangle and placed upon the tripod stand in the centre of the gas flame, which has been previously ignited and surrounded with any draught-protecting device that may be necessary. The hydrocarbon gases commence to escape from under the lid as soon as the crucible attains a red heat, and these burn with a yellow and smoky flame, for a period which depends upon the percentage of volatile matter in the fuel.

As a rule the gas evolution lasts from one to one and one-half minutes with bituminous fuels, and its duration and volume enables one, with a fair degree of accuracy, to judge the character and nature of the fuel. As soon as the last luminous "candle" has disappeared from the Bunsen flame above the crucible lid, the crucible is removed from the flame, very carefully, by lifting away the tripod which supports it without disturbing the lid, and is allowed to go nearly cold in the air, before placing it in the desiccator.

When quite cold it is then weighted with the lid still on, and from the loss in weight, the percentage of volatile matter, coke and fixed carbon is calculated as already described. The final weighing must be within one milligramme. The deposit of soot found upon the inner surface of the lid, and the deposit of graphite upon the inner walls of the crucible, are ignored in the final weighing, since although they appear to be of considerable volume and importance, they weigh only from three to five milligrammes.

The coke left in the crucible after the expulsion of the hydrocarbon gases is very hygroscopic, and on this account it should not be exposed to the air before weighing. The appearance and character of the coke differs greatly with different coals, and it may be obtained either as a powdery non-adhering residue or as a solid cake. With the South Wales steam coals, which cake together on heating, a slight explosion often occurs during the coke test, and some of the fuel is generally thrown out of the crucible. This effect appears to be due to the formation of an impermeable crust of coke around the fuel, before all the volatile matter has escaped.

The best way to obtain correct coke tests, with this and similar fuels which produce detonations, is to use only 0.70 or 0.50 gramme for the test, in place of one grammme.

6—Sulphur—The determination of sulphur in fuel involves the performance of an ordinary gravimetric analysis, and some practice in quantitative analysis will be necessary before accurate results can be obtained. It is therefore useless to attempt this test without some training in the methods and apparatus used by chemists in analytical work. The directions for carrying out this determination are consequently only given in condensed form.

If a bomb calorimeter is used for finding the calorific value of the fuel, the determination of the sulphur is simplified, for the liquid obtained by rinsing out the bomb after the explosion contains all the sulphur in the form of sulphate. The whole of the rinsings are transferred to a porcelain basin, and are evaporated to dryness with addition of five cubic centimetres of pure hydrochloric acid (1.18 S. G.) in a water-bath, in order to remove the nitric acid formed by oxidation of the nitrogenous constituents of the coal. The residue is dissolved in 100 cubic centimetres of water, two cubic centimetres of pure hydrochloric acid are added, and the solution is filtered before precipitating the sulphur with barium chloride. Boiling the solution for five minutes after the addition of the barium chloride renders the precipitate more dense, and less likely to pass through the filter paper.

The remainder of the determination is carried out in the usual way. The weight of barium sulphate finally obtained multiplied by 0.1375 gives the corresponding weight of sulphur, and this multiplied by 100 and divided by the weight of fuel used in the calorimeter, gives the percentage of sulphur present in the coal.

Should a bomb calorimeter not be available, the sulphur in the fuel must be oxidised by means of lime or magnesia and sodium carbonate, according to the method described by Garrett & Lomax. One grammme of the fuel is placed in a small platinum crucible and is intimately mixed with four grammes of a mixture of four parts of pure lime to one of a hydrous sodium carbonate. The crucible is completely filled with this lime-soda mixture, and a larger platinum crucible is then placed over the smaller one, mouth downward. The two crucibles are now inverted and the space between the two is filled with the same lime-soda mixture. The mouth of the larger crucible is covered with a small square of thick asbestos board, and the whole is placed in a muffle furnace heated to bright redness. Distillation of the volatile portion of the coal occurs in about two minutes, and as soon as a flame appears round the asbestos board, this may be removed. To ensure complete oxidation of the carbon, the heating must be continued for two hours. The contents of the crucible are then allowed to cool, brought into water, and the sulphides oxidized to sulphate by means of bromine. The solution is then made acid with hydrochloric acid, filtered, and the sulphur determined in the filtrate by precipitation with barium chloride in the usual way. The calculation of the percentage of sulphur in the fuel is made as before.

(To be continued.)

Electrical Spectacle at Baltimore, Md.

A feature of the Baltimore (Md.) jubilee week, beginning Monday evening, September 10, was the electrical illumination. The downtown section, including the city hall, court-house and other buildings, was brilliantly illuminated. The distribution of the lights was approximately as follows: city hall, 3,500; court-house, 4,000; streamers, 4,000; arch, Hopkins place and German street, 250; Wells and McComas monument, twenty-five; governor's reviewing stand, 100; markers outlining the burned district, 250; city hall reviewing stand, 300, making a total of 14,325 incandescent lamps.

The National Association of Cotton Manufacturers.

ELECTRICAL REVIEW

September 22, 1906

ASPECTS OF THE INNER STRUCTURE OF METALS.1

BY J. A. EWING.

I intend to devote this address to considering in certain aspects the inner structure of metals and the manner in which they yield under strain. It will not be disputed that this is a primary concern of the engineer, who in all his problems of design is confronted by the limitations imposed on him by the strength and elasticity of the materials he employs. It is a leading aim with him to secure lightness and cheapness by giving to the parts such dimensions as are no larger than will secure safety, and hence it is of the first importance to know in each particular case how high a stress may be applied without risk of rupture or of permanent alteration in form. Again, the engineer recognizes the merit, for structural purposes, of plasticity as well as strength, and in many of his operations he makes direct use of that property, as in the drawing of wires and tubes or the flanging of plates. He is concerned, too, with the hardening effect that occurs in such processes when work is expended in permanently deforming a metal in the cold state, and also with the restoration to the normal condition of comparative softness which can be brought about by annealing. Nor can he afford to be indifferent to the phenomena of “fatigue” in metals, which manifest themselves when a piece is subjected to repeated alternations or variations of stress—fatigue of strength or fatigue of elasticity, which, like physiological fatigue, admits, under some conditions, of rest-cure, inasmuch as it tends to disappear with the lapse of time. No apology need be made in selecting for a presidential address to Section G a subject that touches so many points of direct practical interest to engineers. It is a subject which for me the additional attraction of lying in the borderland between engineering and physics—a borderland in which I have often strayed, and still love to stray, and I enter it to-day even at the risk of wandering into regions which, to engineers, may seem a little remote from home, regions where the landscape has, perhaps, a suspicious likeness to that of the country over which the learned men of Section A hold rule.

To engineers, quite as much as to physicists and chemists, we owe in recent years an immense extension of knowledge regarding the structure of metals. This has come about mainly by the intelligent use of the microscope. Take any piece of metal, in the state in which an engineer makes use of it, polish and lightly etch its surface, and examine it under the microscope, and you find that it is a congeries of a multitude of grains, every one of which may be proved to be a crystal. It is true that the boundaries of each grain have none of the characteristics of geometrical regularity which one is apt to look for in a crystal; but the grain is a true crystal for all that. Its boundaries have been determined by the accident of its growth in relation to the simultaneous growth of neighboring grains—the grains have grown, crystal fashion, until they have met, and the surface of meeting whatever shape it may happen to take, constitutes the boundary. But within each grain there is the true crystalline characteristic—a regular tactical formation of the little elements of which the crystal is built up. It is as if little fairy children had built the metal by piling brickbats in a nursery. Each child starts wherever it happens to be, placing its first brickbat at random, and then piling the others side by side with the first in geometrical regularity of orientation until the pile, or the branches it shoots out, meets the advancing pile of a neighbor; and so the structure goes on, until the whole space is entirely filled by a solid mass containing as many grains as there have been nuclei from which the growth began.

We now know that this process of crystallization occurs not only in the solidification of a metal from the liquid state, but in many cases during cooling through a “critical” temperature when the metal is already solid. We know also that the process may in certain conditions go on slowly at very moderate temperatures. We know also that the process of annealing is essentially the raising of the metal to a temperature at which recrystallization may take place, though the metal remains solid while this internal rearrangement of its particles goes on. Whether crystallization occurs in solidifying from the liquid or during the cooling of an already solid piece, it results in the formation of an aggregate of grains, each one of which is a true crystal. Their size may be large or small—in general, quick cooling means that a crystallization starts from many nuclei, and the resulting grains are consequently small; with very slow cooling you get a gross structure made up of grains of a much larger size.

For simplicity of statement I shall ask

1 Address to the engineering section of the British Association at the recent meeting in York.

you in what follows to confine your attention to simple metals, omitting any reference to alloys. Alloys present many complexities, into which we need not at present enter. With simple metals every crystalline grain is made of the same substance: the elementary brickbats are all exactly alike, though there may be the widest variation from grain to grain as regards the form of the grain, and also as regards the direction in which the elementary brickbats are piled. In any one grain they are piled with perfect regularity, all facing one way, like a regiment of perfectly similar soldiers formed up in rows, where each man is equidistant from his neighbors, before and behind, as well as to right and to left. Or, perhaps, I might compare them to the well-drilled flowers of an early Victorian wall-paper.

It was shown by Mr. Rosenhain and myself that when a piece of metal is strained beyond its limit of elasticity, so that permanent set is produced, the yielding takes place by means of slips between one and another portion of each crystal grain. A part of each crystal slides over another part of the same crystal, as you might slide the cards in a pack. It is as if all the soldiers to one side of a given line were to take a step forward, those on the other side remaining as they were, or as if all the men in the front rows took a step to the left, while those in the rows behind kept their places. In other words, the plasticity which a metal possesses is due to the possibility of shear on certain planes in the crystal that are called “cleavage” or “gliding” planes. Plastic yielding is due to the occurrence of this shear; it may take place in three or more directions in a single grain, corresponding to the various possible planes of cleavage, and in each direction it may happen on few or many parallel planes, according to the extent of the strain to which the piece is subjected. Examine under the microscope the polished surface of a piece of metal which has been somewhat severely strained after polishing, and you will find that the occurrence of this shear or slip is manifested on the polished surface by the appearance of little steps, which show themselves as lines of narrow bands when looked at from above. To these we gave the name of slip-bands. Just as the piece of metal is an aggregate of crystal grains, the change of shape which is imposed upon it in straining is an aggregate effect of the multitude of little slips which occur in the grains of which it is made up.
Each grain, of course, alters its form in the process. Speaking broadly, this distortion of the form of any one grain by means of slips leaves it still a crystal. If part of the group of brickbats moves forward, keeping parallel to themselves and to the others, the formation remains regular, except that a step is formed on the outermost rows; the orientation of the elements continues the same throughout. Considerations which I shall mention presently lead to some qualifications of this statement. I now see reason to believe that in the process of slip there is a disturbance of the elementary portions, or brickbats adjoined to the plane of slip, which may alter their setting, and thereby introduce to a small extent some local departure from the perfectly homogeneous orientation which is the characteristic of the true crystal. In very severe straining there may even be a wide departure from true crystalline character. We shall recur to this later; but meanwhile it will suffice to say that substantially the slip which is involved in a plastic strain of moderate amount is a bodily translation, parallel to themselves, of part of the group of elementary brickbats or molecules which build up the grain. If a crystal whose form has been altered, even largely, by such straining, is cut and polished and etched, it appears, under the microscope, to be to all extents and purposes as regular in the tactical grouping of its elements as any other crystal.

Further, in the process of straining we have, first, an elastic stage, extending through very small movements, in which there is no dissipation of energy and no permanent set. When this is exceeded, the slip occurs suddenly; the work done: straining is dissipated; if the straining force is removed, a strain persists, forming a permanent "set"; if it continues to act it goes on (within certain limits) producing augmented strain. In general a large amount of strain may take place without the cohesion between the gliding surfaces being destroyed. Immediately after the strain has occurred there is marked fatigue, showing itself in a loss of perfect elasticity; but this will disappear with the lapse of time, and the piece will then be harder than at first. If, on the other hand, a process of alternate straining back and forth be many times repeated, the piece breaks.

These are now familiar facts. Can we attempt to explain them on the basis of a molecular theory which will at the same time offer a clue to the process of crystall-building as we find it in metals? I venture to make this address the occasion of inviting attention to some more or less speculative considerations which may be held to go some little way toward furnishing the material for such an explanation.

At the Leeds meeting of this association in 1890 it was my privilege to bring forward certain contributions to the molecular theory of magnetism, and to show a model which demonstrated that the rather complex phenomena of magnetization were explainable on the very simple assumption that the magnetic molecules are constrained by no other forces than those which they mutually exert on one another in consequence of their polarities. From this were found to result all the chief phenomena of permeability and magnetic hysteresis. Let us attempt to-day to apply considerations of a similar character to another group of physical facts—namely, those which are associated with the crystalline structure of metals and with the manner of their yielding under strain. Just as in dealing with magnetic phenomena, I take as starting point the idea that the stability of the structure is due to mutual forces exerted on one another by its elementary parts or molecules, and that the clue to the phenomena is to be sought in the play of these mutual forces when displacement of the molecule occurs.

Iron and most of the useful metals crystallize in the cubic system; for simplicity we may limit what has to be said to them. Imagine a molecule possessing polarity equally in three directions, defined by rectangular axes. We need not for the present purpose enquire to what the polarity along the axes is due; it will suffice to assume that it in molecule has six poles, three positive and three negative, and that these repel the like and attract the unlike poles of other molecules. We may make a model by using three magnetized rods fixed together, and, with the assistance of Example, which is essentially a repetition of this argument (Fig. 2).

Along each row the polarity preserves the same direction, but the polarity of each row is opposite to that of each contiguous parallel row. This description applies equally to all three axes. The whole group (Fig. 3) consists of the quartettes of Fig. 2 piled alongside of, and also on top of, one another. In this way we arrive at what I take to be the simplest possible type of cubic crystal.

In this grouping each molecule has the alignment giving maximum stability, and it seems fair to assume that it will take that alignment when the crystal grain is formed under conditions of complete freedom, as in solidifying from the liquid state. As a rule, the actual process of crystal-building goes on dendrically: branches shoot out, and from them other branches proceed at right angles, leaving interstices to be filled in later. We have, therefore, to conceive of the molecules as piling themselves preferably in rows rather than in blocks, though ultimately the block form is arrived at. In this position of maximum stability each molecule has its six poles touching poles of contrary name.

Now comes a point of particular im-
portance. Imagine two neighboring molecules in the same block to be turned round, each through one right angle, in opposite senses. They will now each have five poles touching five poles of contrary name, but the sixth pole will touch a pole of the same name as itself. They are still stably situated, but much less stably than in the original configuration, and they will revert to that configuration if set swinging through an angle sufficient to exceed the limited range within which they are stable in the new position.

Similarly we may imagine a group of three, four or more molecules, each to be turned through a right angle, thereby constituting a small group with more or less stability, but always with less than would be found if the normal configuration had been preserved. The little group in question may be made up of molecules in a row, or it may be a quartette or block, or take such a form as a T or L. A sufficient disturbance tends to resolve it into agreement with the normal tactics of the molecules which build up the rest of the grain. It is conjecturally possible that small groups of this kind, possessing little stability, may be formed during the process of crystallization, so that here and there in the grain we may have a tiny patch of dissenters keeping harmony with their environment.

If this happens at all during crystallization, it would seem less likely to happen in free crystallization from a liquid state than in the more constrained process that occurs when a metal already in the solid state recrystallizes at a temperature far below its melting point. Though rare or absent in the first case, it might occur frequently in the second. There are differences in the appearance of crystal grains under the microscope in metal as cast and in metal as recrystallized in the solid state, of which this may be the explanation. It may also explain a difference pointed out by Rosenhain,\(^1\) that the slip lines in cast metal are straight and regular, whereas in wrought iron and other metals, which have recrystallized in the solid, they rarely take a straight course across the crystal, but proceed in jagged, irregular steps. These may be due to the presence here and there of small planes of weakness, resulting from the existence of what I have called dissenting groups. Again, these groups, possessing, as they do, less stability than their normal neighbors, may be conjectured to differ from the normal parts of the grain in respect of electrolytic quality, and to be more readily attacked by an etching reagent. Hence, perhaps, the conspicuous isolated geometrical pits that appear on etching a polished surface of wrought iron.

It will help in making clear these points, and others that are to follow, if we study the action of a model formed by grouping a number of polarized "molecules" in one plane, supporting them on fixed centres, about which they are free to turn. In the model before you the centres are uniformly shaped in rectangular rows, and the "molecules" are \(\pm\)-shaped pieces of hardened steel, strongly magnetized along each of the crossed axes, each having, therefore, two north poles and two south poles. The third axis is omitted in the model, the movement to be studied with the help of the model being movement in one plane. On placing these molecules on their centres they readily take up the position already indicated in Fig. 3. Each one within the group has its four poles in close proximity to four poles of contrary name, and is, therefore, highly stable. If disturbed by being turned through a small angle, and let go, it swings back, transmitting a wave of vibration through the group, which is reflected from the edges, and is finally damped out in the model by friction and air friction. We may assume some damping action (say by the induction of eddy currents) in the actual solid, of which the model may be taken as a very crude representation.

By turning two molecules carefully round together, each through one right angle in opposite senses, we set up a dissenting pair whose equilibrium has feeble stability. A slight displacement, such as might be produced by the transmission of a vibrational wave, breaks them up, and they swing back to the normal configuration, giving out energy, which is taken up by the rest, and is ultimately dissipated. By making the dissenting coterie consist of three or more we can give it additional strength.


**ELECTRICAL REVIEW**

An example is shown in Fig. 4, where the three molecules marked \(a, b\) and \(c\) are turned round in this way.

Notice that the normal molecule \(d\), adjoining a line of such dissenters, is in a peculiar position. His neighbors present to him three north poles and one south pole. He has the choice of conforming to the majority, or of throwing in his lot with the dissenters; and he has a third possible position of equilibrium (very feeble equilibrium), which is reached when his two south poles are turned until the one neighboring south pole faces just between them. I have labored these points a little because they seem important when we come to speak of the effects of strain.

Consider now the straining action, which we may imitate in the model by sliding one part of the group past the other part. For this purpose the centres are cemented to two glass plates, which can slide parallel to one of the axes.

At first, when the displacement by sliding is exceedingly small, the strain is a purely elastic one. The molecules adjacent to the plane of sliding pull one another out a little, but without breaking bonds; and if in this stage the strain is removed, by letting the plate slide back to its original position, there is no dissipation of energy. The work done in displacing the molecules is recovered in the return movement. We have here a representation of what happens between each pair of adjoining rows in the elastic straining of a metal. So far the action is within the limit of elasticity; it leaves no permanent effect; it is completely reversible.

But now let the process of straining be carried further. The opposing molecules try to preserve their rows intact, but a stage is reached when their resistance is overcome; the bonds are broken, and they swing back, unable to exert further opposition to the slip. The limit of elasticity has now been passed. Energy is dissipated; set has been produced; the action
is now no longer reversible. The model shows well the general disturbance that is set up in molecules adjoining the plane of slip, which we may take to account for the work that is expended in a metal in producing plastic strain.

Moreover, when the slip on any plane stops and the molecules settle down again, the chances are much against their all taking up the normal orientation which they had before the disturbance. What I have called dissenting groups, or unstable centers, are formed as a result of the disturbance. Here and there like poles are found in juxtaposition. Viewed as a whole, the molecular constitution of the metal in the region adjacent to the plane of slip is now uncertain and patchy. It includes parts whose stability is much less than normal. Individual molecules or small groups in it are very feebly stable; a touch would make them tumble into positions of greater stability.

Observe how all this agrees with what we know about the nature of plastic strain through experiments on iron or other metals. Its beginning is characteristically jerky. Once the critical force is reached, which is enough to start it, there is a big yield, which will not be stopped even by reducing the amount of the straining force.

Again, we know there is a slow creeping action that continues after the straining force has done its main work. I ascribe this to the gradual breaking up of the more unstable groups which have been formed during the subsidence of disturbance in the earlier stage of the slip.

Further, we know that overstrained iron is very imperfectly elastic until it has had a long rest, or until it has been raised for a short time to a temperature such as that of boiling water. This is to be expected when we recognize the presence of unstable individuals or groups resulting from the overstrain. When the elasticity of the overstrained piece is tested by removing and reapplying the load, some of these tumble into new positions, making reversible movements, which dissipate energy and produce hysteresis in the relation of the strain to the stress although the strain is quasi-elastic. At ordinary temperatures these unstable groups are gradually becoming resolved, no doubt through the action of the molecular movements that are associated with heat, and hence the slow progressive recovery of perfect, or nearly perfect, elasticity shown by the experiments of Muir. Let the temperature be raised and they disappear much more quickly; in warm surroundings the rest-cure for elastic fatigue does not need to be nearly so long.

Rosenhain has recently shown that after the slip-bands on the surface of an overstrained specimen have been obliterated by polishing, traces of them will reappear on etching if only a short interval of time is allowed to lapse since the overstraining; but if time is given for complete recovery no traces are found. This is in remarkable agreement with the view now put forward, that the layers contiguous to the surface of slip contain for a time comparatively unstable groups. They are consequently different from the normal metal until the unstable groups are resolved, and the temporary difference manifests itself on etching, provided that is done while the difference still exists.

From the engineer's point of view, a much more important matter than this fatigue of elasticity is in the fatigue of strength that causes fracture when a straining action is very frequently repeated. Experiments which I made with Mr. Humphrey showed that this action begins with nothing more or less than slight slip on surfaces where the strain is locally sufficient to exceed the limit of elasticity. An alternating stress, which makes the surfaces slip backwards and forwards many thousands, or it may be millions, of times alternately, produces an effect which is seen on the polished surface as a development of the slip lines into actual cracks, and this soon leads to rupture.

We have, therefore, to look for an effect equivalent to an interruption of continuity across part or the whole of a surface of slip, an effect progressive in its character, becoming important after a few rubbings and, if the movement is violent, but only after very many rubbings if the movement is slight.

That there is a progressive action which spreads more or less into the substance of the grain on each side of the original surface of slip was clearly seen in the experiments referred to. It was found that a slip-band visible on the polished surface of the piece broadened out from a sharply defined line into a comparatively wide band with hazy edges, and this was traced to an actual heaping up of material on each side of the slip which constituted the original line.

I think this suggests that under alternating stresses which cause repeated backward and forward slips, these do not occur strictly on the same surface in the successive repetitions, and hence the disturbance spreads to some extent laterally. It may be conjectured that slip on any surface leaves a more or less defective alignment of the molecular centres; that is to say, the rows on one side of the plane of slip cease to lie strictly in line with those on the other side. If this occurs over neighboring surfaces, as a result of slips on a number of parallel planes very close together, the metal throughout the affected region loses its strictly crystalline character, and with it loses the cohesion which is due to strict alignment.

G. T. Beilby, in a very suggestive paper, has advanced grounds for believing that portions of a metal may pass from a crystalline to an amorphous formation under the mechanical influence of severe strain, as in the hammering of gold leaf or the drawing of wire, and that this occurs in the polishing of a metallic surface, and also in the internal rubbing which takes place at a surface of slip within the grain. In both cases he suggests the formation of an altered layer. When a polished metal surface is etched, the altered layer is dissolved away, and the normal structure below it is revealed.

Without accepting all Mr. Beilby's conclusions, I think the idea of an altered and more or less amorphous layer is supported by the considerations I am now putting forward. We have assumed that in normal crystallization the intermolecular forces lead to a normal piling, in which each molecule touches six neighbors. But it may be conjectured that some of them may take up pyramidal piling (touching twelve others) under the compulsion of strong forces—such forces, for example, as act on the superficial molecules of a surface that is being polished.

If this also occurs at a surface of slip, it gives us a clue to several known facts. It at least assists in explaining the familiar result that metal is hardened by straining in the sense of being made less plastic. Again, it accounts for the general increase of density which is found to take place in such an operation as wire-drawing. Further, if a local increase of density occurs in the interior of a grain through piling of some molecules in the closer manner where repeated slips are going on, the concentration of material at one place requires it to be taken from another; the temperature be raised and they disappear much more quickly; in warm surroundings the rest-cure for elastic fatigue does not need to be nearly so long.
in other words, the closer piling tends to produce a gap or crack in the neighborhood where it occurs. This is consistent with what we know of the development of cracks through repeated alternations of strain.

Recourse to the model shows that with pyramidal piling the polar axes point in so random a manner that the aggregate region on which slip occurs. The hardness may fairly be called amorphous. To illustrate this a group is shown with centres fixed at the corners of equilateral triangles.

It is obvious that any pyramidal piling at a surface of slip tends to bar further slip at that particular surface. Hence, not only the augmented hardness due to strain, but the tendency in repeated alternations to lateral spreading of the region on which slip occurs. The hardness due to straining is, of course, removed when we raise the metal to such a temperature that complete recrystallization occurs. Normal piling being then restored in the new grains.

Taking a previously unstrained piece, it is clear that the facility with which slip will occur at any particular surface of slip in any particular grain depends not only on the nature of the metal and on the orientation of the surface in question to the direction of the stress, but also on the amount of support the grain receives from its neighbors in resisting slip there. In other words, for a given orientation of surface the resistance to slip may be said to consist of two parts; one is inherent in the surface itself, and the other is derived from the position of the grain with reference to other grains.

To make this point clear, think of a grain (under stress) in which there is a gliding surface oriented in the most favorable direction for slipping. Slip on this surface can take place only when its yielding compels the neighbors (which are also under stress) to yield with it, and the surfaces in these on which slip is compelled to occur are, on the whole, less favorably situated. Hence the original grain can not yield until the stress is considerably in excess of that which would suffice to make it yield if it stood alone, or had neighbors equally favorably inclined.

Apply this consideration to the case of steel, where there are two classes of grain—the ferrite, which is simply iron, and the pearlite, which is a harder structure. Slip on any ferrite grain is resisted partly by the strength of the surface itself, and partly by the impossibility of its yielding without forcing slip to take place on neighboring (harder) grains. Now suppose the structure is a very gross one, such as Mr. Stead has shown may be found in steel that is seriously overheated. On the large grains of ferrite in overheated steel the resistance to slip will be but little greater than it would be in iron, and, consequently, under an alternating stress fatigue of strength, leading to rupture, may be produced by a very moderate amount of load. Mr. Stead has shown how the effects of overheating can be removed by the simple expedient of raising the steel to a temperature sufficient to cause recrystallization—a homeopathic remedy that transforms the gross structure of the overheated metal into an ordinarily fine structure, where no ferrite grain can yield without compelling the yielding of many pearlite grains. Hence we find, as Rogers has demonstrated by experiment, that steel cured by reheating from the grossness of structure previously produced by overheating has an immensely increased power to resist the deteriorating effects of often repeated stress.

I trust you will not feel I have abused the license of the chair in presenting contributions to molecular theory that are for the most part in the nature of speculative suggestions, thrown out in the hope that they may some time lead to fuller and more definite knowledge. Remote as they may seem to be from the concerns of the workaday engineer, they relate to the matter which it is his business to handle, and to the rationale of properties, without which that matter would be useless to serve him. We have attempted to penetrate into its very heart and substance in order the better to comprehend the qualities and functions on which the practical work of engineering relies. The man whose daily business leads him through familiar tracks in a forest does well to stray from time to time into the shady depths that lie on either hand. The eyes of his imagination will be opened. He will at least learn his own limitations, and, if he is fortunate, he may gain some clearing on a hilltop which commands a wider view than he has ever had before.


ELECTRICAL REVIEW

BOOK REVIEWS.


This volume is put out as a complete engine operators' catechism, and it is the aim of the author to enable the careful student of it to obtain a certificate for operating marine engines. The subjects of heat and combustion are first taken up, followed by a consideration of the boiler and its appurtenances; a chapter is devoted to the care and operation of boilers, and finally engines and auxiliary machinery are discussed. While not all the explanations are put in a strictly scientific way, the manner of presentation is possibly one which will appeal to the class of readers sought.


For many years this little book was not only the standard, but the only, work of its kind available for men in charge of electrical machinery. It is so well known that there is no need, in calling attention to the new edition, to do more than state that this has been brought up to date. A large amount of new and amended material dealing with the management of alternating-current generators and motors, both single-phase and polyphase, and railway motors, has been added. Although the field to be covered is now much larger than when the book was first issued in 1892, by eliminating those parts dealing with machines no longer in use, the volume has been prevented from becoming bulky. For those whose business it is to keep a machine in order, and who have not had that training in theory which will assist in locating troubles, this book is invaluable; and, at the same time, it is of great-assistance to those who have had book training, but whose experience with electrical machinery in actual service has been limited.


An attempt has been made here to produce a book dealing with the intricate subject of steam turbine design, but which shall not be deeply involved in mathematics. The attaining of exceedingly high thermal efficiencies is not insisted upon, but rather is the practical and workable
type of machine considered. The author discusses clearly the different types of turbines, such as the action and reaction, and describes practically all the principal types that have been built. The various elements in design, such as the nozzles, blades, construction of rotor, methods of governing and bearing construction, are taken up in order, and the various actions coming into play during operation are explained and methods of providing for them suggested. A chapter on steam turbine performance gives some characteristic results and an analysis of the losses which take place. Both stationary and marine types of turbines are described.


This is one of a series of papers written for the practical man. The work takes up in detail the calculations involved in installing a simple two-wire or three-wire system for incandescent lighting. The familiar formulae for calculating the carrying capacity and resistance of circuits are given, and there are several diagrams showing the layout for wiring a typical residence.


A most interesting account is given here of the development and adoption of the metric system of weights and measures in Europe, and the progress which has been made in its use in various countries. While the authors are admittedly supporters of the metric propaganda, they have not taken up the subject in a controversial manner. They have prepared this book to serve as an introduction to metrological science and to make available an intelligent work dealing with the metric system. The metric system has resulted not from a sudden impulse, but is the growth of over a century of careful study and discussion. While it is very probable that it would not have been adopted by France as early as it was had it not been for the disturbing conditions of that country at the time, this fact does not in any way detract from the value of the work that has been given to this development. In fact, the original committee to whom was assigned the task of preparing a truly scientific system of metrology consisted of men in the first rank of science. The story of the difficulties encountered and the opposition they overcame in their work is exceedingly interesting. The book starts with a discussion of the beginnings of the science of metrology, describes the origin and development of the metric system and its extension throughout Europe and elsewhere, then takes up a discussion of the weights and measures in use in this country and the use of the metric system in commerce, engineering, pharmacy and science. It is a work which may be read with profit by all those who are interested in metrology, whether they be supporters or opponents of the metric system. To the book is added a useful appendix, giving tables of equivalents and a number of useful physical constants.


New text-books for students of electrical engineering have not been lacking of late, but seldom has the reviewer had the pleasure of examining one which seems so well fitted to meet the requirements of teaching in our technical schools. The demands made on the various engineering departments at these schools are various in order to meet the requirements of the different classes of students. The problem of obtaining a text-book, or even a set of text-books, that will supply the needs at an expense not prohibitive is difficult. The authors of this book, realizing from a long experience in teaching the needs and difficulties, have decided to lay the greatest stress upon the fundamental principles, and only pass to details when this will assist in the understanding. With this idea in view the first part of the book explains the fundamental laws of electricity and magnetism and how these are applied in the dynamo and motor. The characteristic behavior of these various machines is discussed, as well as their performance as energy converters. The methods of ratings machines are carefully explained and some instructions given for the care and operation of dynamos and motors. This is the ground covered by the book proper. The discussions are clear and satisfactory and not at all mathematical, so that this part is suitable for the use of students who are not making a specialty of electrical engineering, as well as being excellently adapted to serve as an introduction for the electrical student. To carry the latter further there is a number of appendices, one on electromagnetism, in which the theory is gone into fully. Another deals with characteristic curves, those tools which are so useful to the electrical engineer. A third appendix makes a study of armature windings, and a fourth gives over 100 practical and instructive examples to be worked out by the student as he progresses through the book. This brief outline will, perhaps, indicate in a way the method of treatment adopted by the authors. As said before, the aim is to instil principles, and not confuse the mind with a mass of so-called practical information. Too many books err in trying to give too much so-called practical data and in trying to catalogue too many types of machines. In the opinion of the reviewer this practice is wrong. Electrical engineering is becoming so broad and practice is advancing so rapidly that it is disheartening to attempt—in fact, it is impossible—to keep up with all advances. What should therefore be done, and what is done here, is a driving home of the fundamental principles upon which electrical engineering is based.

The Adirondack Murray Memorial Association.

Quite a number of electrical men have become interested in the recently organized Adirondack Murray Memorial Association, which provides for the perpetuation of the memory of Adirondack Murray. The objects of the association will be to erect a suitable monument at his burial place, to preserve the homestead at Guilford, Ct., to assist in the education of his daughters, and to promote the sale of his books.


The officers of the association are: Edward Griswold, a classmate and lifelong friend of Mr. Murray, president; M. J. Hapgood, treasurer; M. F. Westover, secretary.

The constitution provides that the membership in the association shall be permanent without annual dues, and that members may be either "regular," "special" or "patron." Any person may become a regular member upon the payment of $2, a special member upon the payment of $5, and a patron member upon the payment of $26, or such larger sum as he may be disposed to give.

The number of rubber trees of all ages in the Federated Malay States is put at six or seven millions. The rubber production of 1905 is estimated to have been 300,000 pounds.
The Meeting of the Electrical Jobbers at Niagara Falls.

As reported in the issue of the Electrical Review for September 15, a meeting of electrical jobbers and manufacturers was held at the International Hotel, Niagara Falls, N. Y., September 11-14. The business programme included division meetings on September 11, both morning and afternoon, and a morning session on September 12. Executive committee meetings were held on the afternoon of September 12, on the morning and afternoon of September 13, and on the morning and afternoon of September 14.

The entertainment programme included a ladies' informal reception in the parlors of the International Hotel, a smoker for the jobbers and manufacturers at the Cataract Hotel, and a rejuvenation smoker for the jobbers and manufacturers in the dining hall of the International Hotel.

On the morning of September 13 a tug-of-war was indulged in between teams representing the Atlantic and Central divisions of the jobbers, and the ladies and manufacturers were given a carriage drive. In the evening there was a trolley ride to the rapids of Niagara Gorge, and later an informal dance in the ballroom of the Cataract Hotel.

On the morning of September 13 a baseball game was held between the manufacturers and the jobbers. In the evening there was a progressive euchre for the jobbers and manufacturers, and a banquet of jobbers and manufacturers was held at the International Hotel, on September 11. On the morning of September 12 a tug-of-war was indulged in between teams representing the Atlantic and Central divisions of the jobbers, and the ladies and manufacturers were given a carriage drive. In the evening there was a trolley ride to the rapids of Niagara Gorge, and later an informal dance in the ballroom of the Cataract Hotel.

On September 14, in the morning, there were sight-seeing trips to various points of interest. At one o'clock a picnic was given at Brock's Monument, Queenstown Heights, overlooking Lake Ontario. It was unfortunate that the rain kept a good many from attending this picnic.

In addition to those mentioned in last week's issue of the Electrical Review, the following attendants and guests arrived late: W. J. Phelps, Frank Stout, E. Ward Wilkins, A. T. Appleton, Norman Marshall, E. A. Jenkins, H. B. Crouse, Thomas Walsh, E. H. Haughton, F. S. Terry, Harry Hart, A. N. Palmer and H. C. Hoovens. The attendance was markedly representative of the jobbing and manufacturing sides of the electrical industry.

The baseball game was the means of creating considerable amusement, and was really one of the most enjoyable features.

Counsel Thomas M. Debevoise officiated as umpire, armed with a pistol and a golfer's guide. The line-up was as follows:

- Electrical manufacturers—Waterman, 1st base; Hart, catcher; Gray, pitcher; Wilkins, 2d base; Gray, 3d base; Walsh, shortstop; Grier, centre field; Crockett, left field; DeVeau, right field.
- Electrical jobbers—Wayman, shortstop; Hopkins, centre field; Turner, left field; Hodge, 3d base; Fletcher, catcher; Hall, 1st base; Hughes, pitcher; Adams, 2d base; Jones, right field.

The peculiar success of this dinner was largely due to the indefatigable efforts of the committee in charge, consisting of Messrs. Robertson, Sibley and Bosley.

At noon of September 14, the meeting adjourned to the Cataract Hotel, and a banquet of jobbers and manufacturers was held at the International Hotel, on September 22. The menu served was as follows:

- Dry Martinis
- Little Neck Clams
- Bisque of Lobster
- Salted Almonds
- Stuffed Grapes
- Crétonne Soufflé
- Cheese straws
- Celery
- Cigars
- Saltines
- Cigarettes

The peculiar success of this dinner was largely due to the indefatigable efforts of the committee in charge, consisting of Messrs. Robertson, Sibley and Bosley.

New York Electrical Society.

The New York Electrical Society will open its season for 1906-1907 with an interesting meeting, on the evening of September 26, at the exhibition offices, 1414 Broadway, New York city, introducing to the electrical public one of the notable inventions of recent years, the Cahill Dynamophone and Telharmonium System. Oscar T. Crosby, the well-known electrical engineer, who is associated with Dr. Thaddeus Cahill in the enterprise, will deliver an address on the subject of the apparatus. An excellent programme of music of all kinds will be presented.

The following papers will be presented:


The menu served was as follows:

- Dry Martinis
- Little Neck Clams
- Bisque of Lobster
- Salted Almonds
- Stuffed Grapes
- Crétonne Soufflé
- Cheese straws
- Celery
- Cigars
- Saltines
- Cigarettes

The peculiar success of this dinner was largely due to the indefatigable efforts of the committee in charge, consisting of Messrs. Robertson, Sibley and Bosley.

Johns Hopkins University Offers Graduate Courses in Applied Science.

The Johns Hopkins University is offering as a part of its regular curriculum advanced courses in applied science. These courses having special bearing on applied science are now offered in biology, chemistry, physics, applied electricity, geology and mechanical drawing. Under physics and allied subjects, courses are given in electrical measurements, applied electricity, photography, theoretical mechanics, the design of instruments and mechanical drawing.

Meeting of the American Institute of Electrical Engineers.

The 299th meeting of the American Institute of Electrical Engineers will be held in the auditorium of the New York Edison Building, 44 West Twenty-seventh street, on Friday, September 28, at 8.15 P. M. Dr. Samuel Sheldon, recently elected president of the Institute, will be officially conducted into office at this meeting. Dr. Sheldon will read his inaugural address, entitled "The Work of the Institute."}

The following papers will be presented:


Electrical Review Review...
Carbon Brushes versus Copper.

Although giving carbon brushes full credit for the assistance they have given in developing electrical apparatus, E. Austin raises the question whether it will not be possible, and perhaps desirable, to return to copper to-day. Although a few years ago carbon was indispensable to prevent sparking, much advance in machine design has since taken place, and the use of commutating poles and other similar devices should enable us to return to copper, the advantage being the lower electrical resistance and the decreased friction, and hence a more efficient and cooler machine. The advantage of doing this will be much greater with the high-speed machines to which we are returning in order to take advantage of the steam turbine, and it is a rather curious fact that continuous-current machines driven by turbines are now run with copper brushes, although, on account of the high-reactance voltage of the armature, they are the ones to which carbon brushes would seem to be the most necessary. The conductivity of carbon is only one-tenth that of copper, and its friction coefficient is 0.3, as against 0.2 for copper. It has been estimated that the efficiency of a fair-sized machine can be raised from two to two and one-half per cent by substituting copper for carbon brushes. Better results can be obtained by using carbon coated with copper or carbon which contains a large percentage of copper; but the efficiency of a machine can always be increased an amount well worth consideration with pure copper alone.—*Abstracted from the Electrical Engineer (London), August 31.*

An Experiment in Industrial Training.

The apprenticeship course of the General Electric Company at West Lynn, Mass., is described here by M. W. Alexander. The object of this course is to train young men as skilled journeymen and to furnish a supply of such men from which foremen and assistant superintendents may be picked. Under this system boys of at least sixteen years of age with a grammar school education are indentured as apprentices in one of the many trades practiced at the West Lynn works. The applicants have to serve a trial period from one to two months, and unless they give promise of becoming good artisans during this period they are not allowed to sign the regular apprenticeship agreement. This agreement provides for a service of four years, during which time the apprentices are paid fair wages along a progressive schedule, and are given every opportunity to learn the arts of the particular trade to which they are indentured. The wage schedule is set so that each boy can be self-supporting from the beginning, even during the trial period. In addition to the work in the shops the apprentices attend school twice a week, each session lasting two and one-half hours. These sessions take place during the working period, and the boys are paid for this time at the regular rate. For this instruction a small shop has been set aside in a large factory which is devoted entirely to the preliminary instruction of apprentices. He serves in this shop for about two years, and is then sent into the regular shop, where he secures still greater skill and accuracy on a greater variety of work. It is said that this school has proved most successful since its inception early in 1905.—*Abstracted from Machinery (New York), September.*


Exception is taken here by T. J. J. See to the recently pronounced theory of the origin of volcanic heat, due to Professor Elihu Thomson; an abstract of which appeared in the issue of the *Electrical Review* for August 25. Dr. Thomson says a truly solid interior seems to be demanded by the accepted great rigidity of the body of the earth. While the author had frequently expressed this view in his writings, he thinks he has since proved conclusively that a fluid substratum underlies the earth's crust. Rigidity really does not disprove internal fluidity, and the geological evidence of the existence of a fluid substratum is overwhelming. He has shown that the required rigidity could be given by a fluid interior, if it were under sufficiently great pressure. He agrees with Dr. Thomson in pronouncing against radium as a source of volcanic action, for, were this the case, abundant eruptions should be expected to occur in all countries underlaid with granite, which is contrary to observation. R. J. Strutt, from his radium investigations, concludes that the internal temperature of the moon exceeds that of the earth, but the observed temperature of the lunar surface contradicts this hypothesis. From this we must be very cautious about ascribing too much to radium. The best experimental evidence available is that radium is a temporary form of matter the energy of which must be renewed from other sources at intervals of 30,000 years, and thus it may play an inappreciable part in the physics of the universe.

There is no evidence that it is an important cosmical agency. The great forces which have most profoundly modified the world will be found to be familiar ones which are overlooked mainly because they are so simple and so near at hand.—*Abstracted from Science (New York), September.*

Practical Notes on Underground Substations.

Some notes dealing with the construction of underground substations, referring particularly to English practice, are given here by W. Pleasance. These substations are intended for the large transformers which take the place of a number of smaller transformers placed on poles. Two general types are recognized—single and double-compartment vaults. As a measure of precaution against possible flooding, it is best to use the type of transformer designed to be placed in a watertight tank. This is bulkier than the unenclosed type for the same output and necessitates a larger chamber. In the single-compartment type of chamber it is necessary to leave a passageway for the inspector. This calls for a somewhat larger chamber. Space may be saved by making a recess in the chamber by which entrance is effected. The chamber should not be less than seven feet high from floor to ceiling. One of the most important features in its construction is to provide watertight walls and floor. This is best done by laying down a foundation of nine inches of concrete with a slope toward one
The Sudden Short-Circuiting of Alternators.

A study is made here by F. Punga of the factors that effect the difference between a gradual short-circuit and a sudden short-circuit. As the matter is rather complicated, an exact solution of the problem seems quite impossible, but a rough approximation may be made. If the generator be short-circuited, the flux in the armature, as well as the pole, has to be changed; and it is this change of flux which changes many of the phenomena observed on the occasion of a sudden short-circuit. During the time this change is taking place a larger flux is entering from the pole shoes into the armature than at the end of the change, and therefore a higher electromotive force is also produced. The maximum short-circuit current may reach a value twenty times larger than the full-load current, and, owing to the change of flux induced in the field-winding acting in the same sense as the exciting voltage, the exciting current is increased. If the generator were standing still the change in field flux would induce the same effect in the armature-winding as in the field-winding. As, however, the field is rotating, the current induced in the armature circuit due to the change of flux is displaced by nearly ninety degrees. In case the armature circuit has a considerable resistance a component of the current induced will have a demagnetizing effect, but, in general, this may be neglected. The armature current at short-circuit does not immediately reach the value corresponding to the induced electromotive force, requiring about one-quarter of the period to grow from zero to its maximum. An analytical examination of the conditions existing at short-circuit leads to the following conclusions: After a sudden short-circuit the field current increases within a quarter of a period to a maximum value. The number of magnetic lines that would be linked with the field circuit if the generator were gradually short-circuited with the preceding maximum value as excitation would be just as large as with normal excitation before the short-circuit. The effect of a sudden short-circuit may be briefly summarized as follows: The excitation current is increased, the exciter is overloaded momentarily to a considerable extent, the armature current reaches a value considerably higher than the normal short-circuit current, and, as a consequence of the high armature current, a considerable force is produced on the pole shoe heads. Even though the armature have a comparatively large ohmic resistance or the short-circuit occur at a distance from the generator, the armature current may still become considerably higher than the normal short-circuit current, and the copper losses may represent a dangerous overload on the generator. The author then gives the results of an investigation of sudden short-circuits on a 5,000-kilowatt alternator. It was found that after a sudden short-circuit the exciting current rose to six times its normal value, while the flux fell to about one-half its normal value. In order to determine the value of the sudden current rush a dead-beat ammeter and a hot-wire ammeter were used, but in either case the readings are merely indications, and are not accurate. It was found that the ammeter in the field circuit at the moment of short-circuit gave maximum deflections about three and one-half times the normal exciting current, while the hot-wire instrument showed that the current rush in the armature was nearly double that taking place on a normal short-circuit. The results point to the advisability of clamping the field spools firmly and of using mechanically strong insulation on the armature. It has been suggested that one method of protecting a generator against such unexpected loads would be to insert an overload switch in the field circuit.—Abstracted from the Electrical Review (London), August 31.
BEST METHODS TO INCREASE BUSINESS
APPLIED TO A VILLAGE OR SMALL
CITY, WHERE THE POPULATION IS NOT
INCREASING.1

BY SAMUEL RUST, GREENVILLE, OHIO.

This subject is a very interesting one to every electric light manager or superintendent, and while it is not the writer's intention to try to cover all of the ground, he will give some of his personal experiences and ideas in trying to secure and maintain a business in a small town or city where the field for new business is limited and where it has been intelligently worked for many years.

In the first place, you will all agree that we must give good service, and in order to do this the manager or superintendent must have reliable men—men who take pride in their work and who make the company's interest their interest. They must be men that are trustworthy, and if any of them have to deal with the customers (and they all do more or less), they should be courteous at all times.

I believe that the central stations should take care of all construction work, such as wiring, etc., for the customers; at least, the company should see to it that the contractor does not charge prices that will tend to prevent prospective customers from installing the wiring; in fact, any work of this class should be installed by the lighting company at nearly cost. In doing this the company should of course use nothing but the very best material and workmanship. The manager or superintendent should make it his duty to convince the customers that the company is giving them value received for everything done for them, that it is his earnest endeavor to favor them as far as possible, and never under any circumstance misrepresent anything. It is far better for your business if you never secure a man for a customer than to get him and lose him because he finds that you have misrepresented something.

I believe that every central station should furnish free renewals, no matter how small the town. It has a pleasing effect on the customer and I believe it a paying business for the company, for the reason that if the customer is compelled to pay for his renewals, you will find him taking lamps from places that are little used, leaving the sockets open, and when he has occasion to use light in these places, he does without. This works two hardships on the company; first, the loss of the current consumed; second, the dissatisfied customer, because he has to use some other kind of light, and perhaps go to some inconvenience in order to accomplish his purpose; whereas, had there been an electric lamp there, he would have turned it on and been pleased with the result.

The successful superintendent in a small town, must, of necessity, be a very busy man. He must be in touch with everything, from the coal pile to the lamp. Must know where his men are, what they are doing at all times, be with them as much as possible, and know that the work along every line of the business is being done in the most economical and best way possible. He should make a study of his customers, know their peculiarities, and see that they are taken care of in a way that will satisfy each individual. It is a deplorable fact that almost every public service company has the reputation of overcharging and mistreating their customers. This feeling may be, and should be eliminated, and I believe that this duty falls upon the shoulders of the superintendent, perhaps, more than any other officer of the company, and by hard and continuous work, by meeting the customers from time to time, listening to their grievances, whether they be real or imaginary, conceding to their whims as far as possible, and constantly bringing before them and impressing on them the fact that their interests are your interests, you can convince them that you are their friends, and that you are serving them rather than trying to overcharge them, and whenever you succeed in gaining their confidence, you will have a friend as long as you prove worthy of their friendship, and that customer will do more good in getting new business than any one you might hire.

Another grave mistake that is made by many small plants, is the arbitrary way they have adopted of furnishing service. Some have certain hours to run, starting at a given hour and shutting down at a certain hour. Others are controlled by the weather, starting when it gets dark and stopping as soon as they think it is light enough to do so. I have found that these things are very annoying and unsatisfactory to the customer. He may have a dark store and will need light, when the majority do not need it and you may shut off the light just at the time when the customer may have an important customer. Now, put yourself in the same place and see how long you will put up with that kind of service. The current should be kept on the lines as much as possible.

You may not make anything in dollars and cents; in fact, you may lose something in operating during the day, but I am sure that the satisfaction will more than recompense you for any outlay that you may make in this direction. The revenue derived from this service may not look like a paying proposition; in fact, it may appear that you are losing by operating your plant at times, but the fact that you are giving satisfaction and that your customer can have what he wants and at the time he wants it, will more than repay for the seeming loss in operating. This kind of service opens up a field for many little things that are a convenience to the customer and incidentally a source of revenue for the company. It gives you a chance to install sewing-machine motors, flat-irons, chafing-dishes and a great many other things that are fully appreciated by your customers.

Another thing that is in favor of the continuous operation of your plant is the fact that you may educate the public to use more light. If they know that they can use it at any time, they will learn to use it at times when ordinarily they have been getting along without it. The fact that they know that they can have the use of the current will tend to have a pleasing effect upon the customer and you all know what that means, not only more revenue from these parties but their influence toward securing other and new business from their friends and this is the end for which we should all be working. The satisfied and enthusiastic customers are the best advertising mediums that a company can secure.

The inducements of good service,
courteous treatment, free renewals and day current will do much to solve the difficulty of slow business, but where this does not bring in the necessary amount of increase desired by a company, special inducements may be employed in some cases to good advantage. Where the company has a day current, and I believe that no company should operate without furnishing a day current, special inducements can be offered that will attract residence customers especially. I have always found that where you could enlist the interests of the ladies in your business you had a strong aid if the inducements were such as to appeal to their ideas of good housekeeping and labor-saving devices. With a day current flat-irons can be made to prove a profitable investment, not supplied free because I have always found that what costs nothing is usually but little appreciated, but supplied at actual cost installed without further cost than the iron. The best method of introducing the flat-iron problem is to order plenty, get consent to install on trial, say nothing about price or cost until they have had a chance to get acquainted with their use. Where irons are furnished at cost, it will be found that less than five per cent will come back to the plant when the time comes to close the contract or remove the irons.

The same rule holds good as to water-heaters, sewing-machine motors, small radiators for bedroom service and other like appliances costing little but adding greatly to the convenience of the household.

One hard problem I have found in pushing residence business has been the immediate cost of wiring in houses that are already occupied. I have not tried collecting for wiring in installments, but I believe that such inducements will be profitable. Where parties are absolutely good I have found it to an advantage to give all reasonable time asked for in paying for wiring. Another inducement is to offer free a nice portable lamp in each residence wired. This does not partake of free wiring but is merely an evidence of good will on the part of the company to induce the customer to stand the inconvenience of having the house wired. I believe that the companies could advertise this as a special inducement for certain months and it would bring in much more than the cost of the lamp. With business houses I have found that furnishing the newest and best method of lighting is an inducement that is always good. In the plant with which I am connected, we would have lost three very desirable department store customers had we not been able to please them with the high-efficiency lamp, and, while they paid for the first installation, all lamp renewals are furnished under the contract. This was sufficient inducement in these cases. I have also found that in small stores where they were dissatisfied with a small installation of lamps or with the use of gas, the installation without cost of one high efficiency would bring about satisfaction, or a change of gas to electricity. No matter how small the town or how unprogressive the business man, if he sees his competitor well lighted and drawing custom for that reason he will listen to inducements for his own lighting.

As I before stated the necessity for the superintendent or business manager of the plant in a small city or town to know and have a business acquaintance with all light consumers is an absolute necessity. Five minutes, two or three times each month, spent in the store of a man who does not use your product with inducements of better light, will eventually get his business.

One of the greatest mistakes some of the smaller central stations are making and perhaps the primary cause of many plants not proving a financial success, is the system of selling current on a flat-rate basis. Many times a superintendent in order to secure business will listen to a prospective customer as to how much current he will use and the hours that he will use it, and basing his calculations on the customer's statement makes a price too low and in a short time finds the same customer using fully double the current he had contracted for. In this case you have no recourse other than to shut him off, making an enemy who will knock your business afterward, or letting him continue at a loss. If there is a superintendent here laboring under such unfavorable conditions, I would say do not sleep after you return home until you put all your customers upon meters, for this is your only salvation. You may hesitate fearing you will lose some business; you may but the probabilities are you will not lose any if they are properly handled; even if you should lose a few, don't worry, as the ones you lose will be the ones that you can not afford to keep on your lines. The first thing to do is to find out as nearly as possible what your current costs to produce and then add to that a fair profit, bearing in mind that you are to now get paid for all you put out, and make your rate as favorable as possible to the customer and never lose sight of the fact that your rate must be one that the consumer can afford to use the current, not as they have been using it but as they need it and as it should be used. If you have the confidence of your people it is not a hard proposition to convince the average business man that you are giving him all that you can afford. With this change you will find that the gross earnings of your plant will increase very materially, and at the same time your output and operating expenses will decrease. I am not giving you theory, but experience. The plant with which I am now connected has within the last two or three years gone through this same experience, and while I was not with the company during the greater part of this change, I know it was a most satisfactory change to both company and customers. In making the change to meters, the company adopted the two-rate system for stores and commercial use, giving the customer the option of the two-rate or straight-meter system. The company went into the question of the cost of production and fixed expenses very thoroughly in order to arrive at the best price that it could give the consumer. It then went to its customers, giving them the reasons for the change and courteously but firmly informing them that the flat-rate system was to be a thing of the past and current would only be sold by meter, and that they might have their option of either current at a nine-cent rate, including the discount or two-rate system with a fixed charge of $3 per kilowatt per month and current at a four-rate cent, or the company would be compelled to discontinue service. No attempt was made to withhold anything from the customer, and the whole matter was dealt with by a heart-to-heart business talk on the injustice of the flat-rate system and the necessity for the meter rate, which would be fair to both parties to the contract. In a city of 7,000 people not a single customer was lost in changing over, and the results have been better satisfied customers, more light used, larger receipts for the company, less operating expenses and more actual profit from the business done.

I do not believe that our company or our city is differently situated from any other company or town or city in the state, and that the same results could be obtained and a sure profitable business had as against a poor business at an unsatisfactory rate under the old flat-rate system.

To recapitulate, I would say that the following will increase business in any town:

**ELECTRICAL REVIEW**

September 22, 1906
Reasonable meter rates, good service, courteous treatment, good wiring at or near cost, free renewals, continuous service, attention to small details, cultivation of acquaintance, careful attention to plant, allow wiring to be paid for in instalments or on reasonably long time, offer such little

company is working to their interests and will do everything possible to render the business relations between the company and the consumer pleasant, agreeable and profitable to both.

From time to time, in various articles

D. W. Low, of the Alliance Gas and Electric Company, stated to the Ohio Electric Light Association at the recent convention that when electric flat-irons came into use he thought it best not to commit his company to any special make, not being convinced which was the best, and he accordingly adopted the policy of letting the supply dealers send samples out on two weeks' trial, which he persuaded them to do, and at the end of the trial period if the party decides to keep the iron and will sign a certificate evidencing that they will purchase same, the lighting company will allow this certificate to be applied as a credit on the light bill to the extent of one dollar. By this method the lighting company does not in any way have to guarantee the irons. Mr. Low concluded by exhorting all managers in smaller places to keep before the public favorably, and if in their places of business in the evenings to make the same a rendezvous for those who may want some little accommodation, such as postage stamps after the post-office is closed, use of telephone, or information such as where a house can be found vacant to be rented, etc.; to be ready, in other words, to at all times accommodate patrons in every reasonable way. In connection with this paper the writer prints blank forms of circular announcements of gas stoves, also blank agreement of purchase, etc.
Allis-Chalmers Motor-Driven Centrifugal Pumps.

The general use of the centrifugal pumps in this country has, until recently, been confined to installations where a low lift was required, but the multi-stage centrifugal pump, for heads ranging as high as 2,500 feet or more, is rapidly coming into general favor.

Among the numerous features that recommend pumps of this type are their low first cost, the small space which they occupy, the light foundations needed, and the limited amount of attention that they require. They are safe to operate, because they will produce no more than approximately the maximum pressure for which they are designed, even if the delivery is almost or entirely stopped by the closing of the valves in the discharge pipe. They are also able to handle gritty waters, and, when made of acid resisting materials, to handle acidulous, corrosive or viscous fluids to good advantage.

The Allis-Chalmers Company, of Milwaukee, one of whose small units is illustrated herewith, designs these pumps for any capacity and conditions of service within the range of their adaptability, and the construction of each is planned with careful reference to the requirements of the service for which it is intended. They may be used in mining operations, for irrigation work, for auxiliary pumping stations in cities, for municipal fire service, for feeding boilers, or for any other service of a similar nature.

The pumps are built with as many runners as there are stages through which the water is required to be handled, each stage raising the total required quantity of water through its proportion of the total net head. The runners are designed after the well-known "enclosed" type, the water entering and leaving each runner axially. All of the runners are mounted on a common shaft. A stationary guide wheel is introduced between each runner, the function of this wheel being to take the water from the tips of the vanes of one runner and conduct it through suitably designed passages to the inlet side of the succeeding or next runner. After the water has passed through the last runner it is guided into the volute-shaped casing. Particular attention is given to securing for these pumps casings of smooth surface, free from irregularities, in order to reduce the hydraulic friction to a minimum; and of those portions of the interior of the pump casing and runners through which the water passes at high velocity all accessible parts are machined. The waterways are of relatively large area, and the contour of the vanes is such as to produce the best results for the particular service required. The pump remains in lateral balance under varying loads and conditions. When properly adjusted, those pumps will run smoothly, without undue jar or vibration, and care has been taken in their design to secure the highest possible efficiency, strength, durability and accessibility.

The pumps may be driven either by induction or direct-current motors. Both pump and motor are mounted on a common bedplate.

The electrically driven pump has a number of important advantages. One of these is that, on account of the high rotative speed, less work needs to be done for each revolution, thus reducing the size of the unit. Pumps directly connected to electric motors are also flexible in their operation. As the speed is constant, the power and output are in inverse ratio to the head pumped against, so that the efficiency remains practically constant within the limits of which the pump is designed. Then, too, the speed necessary for operating under high heads can be obtained without increasing the impeller diameter of the pump to such an extent as to render its construction impracticable. Further, it sometimes becomes necessary to erect pumping machinery at a distance from the source of power, and in such cases the use of electric current greatly simplifies the problem of construction.

New Cleats and Break-Arms.

Believing that there is room for improvement even in quite familiar types of electric line material, the Ajax Line Material Company, of Chicago, Ill., is supplementing its line of original insulators and fixtures with improved types of older devices. Two of these are pictured herewith, both showing how neater forms can be obtained without sacrificing strength or increasing the cost. The "Cast Pin Break-Arm" has the usual twelve-inch spread, while the Ajax cleat has a nine-inch length (an inch more than usual) and hence will take a greater length of hoisting rope. Besides, it has a curved back, so that it will not rock on the pole, while the galvanized finish makes it extra durable.
A New Line of Alternators.

The first and simplest form of electric generator, a single coil rotating between two magnetic poles of opposite polarity, was essentially an alternator. As the chemical generator, or battery, preceded the mechanical generator, or dynamo, the early conception was of a unidirectional current. Hence, the commutator was added to the early dynamo, and little use was found for alternating current. The modern trend of electric development, however, toward distant transmission and higher voltages has made the alternating current, with its advantages of transformation, greater simplicity in generating apparatus, and greater case in insulating the stationary generator coils, a prevailing form in which electrical energy is now transmitted when any great distance is to be covered.

The Western Electric Company, in addition to its already developed line of direct-current apparatus, has just completed the design of a line of alternating-current generators. A number of machines have been installed during the past year and are giving the best of satisfaction.

The position of a company with the facilities and experience of the Western Electric Company in taking up the manufacture of alternators at this time is particularly fortunate. The stage of development during which all sorts of alternator designs were evolved and placed upon the market is past, and now a standard form of alternator, having a stationary armature and an internal revolving field separately excited by direct current, has come to be the generally accepted type. After carefully studying the conditions which prevail in the high-voltage alternating-current apparatus, this company is now producing and installing a line of alternators in all of the standard types, speeds and frequencies which it confidently believes to be of the best design and construction. With no old and obsolete patterns and dies to hamper the design, and with a general knowledge of the present-day class of machines, a complete line has been laid out in which each part is the best that can be produced under any conditions, and the best adapted to its particular function.

From the standpoint of the purchaser,
the three most important features considered in selecting an alternator are heating, regulation and efficiency. These features are given especial consideration in the design and manufacture of Western Electric alternators.

The heating is kept low by a generous design of those parts developing heat. The working densities are low and the radiating surfaces large. All coils are so constructed as to have unusually good heat-conducting properties, and an open construction ensures excellent ventilation.

Specially good regulation is obtained by so proportioning the parts of the machines as to reduce the two quantities which tend to cause poor regulation. The local self-induction of the armature circuit, and the back and cross-magnetizing tendency of the armature current, are reduced to a minimum. Self-induction is reduced to a minimum by the use of windings as widely distributed as possible, shallow open armature slots, and such a form of armature connection as will minimize the local leakage. The back and cross-magnetization of the armature current is also reduced by this distribution of the windings and by the form of end connections. Large running clearance is used, thus improving the regulation by reason of a greater excitation being required, and a consequent stiffer field. The efficiencies of these alternators are high. Depending as they do upon the copper and iron losses in the engine type, and the copper, iron and frictional losses in other types, a careful proportioning of these losses has produced machines with high efficiencies. While good ventilation is a feature, in no case is this taken advantage of to reduce the active material so as to impair efficiencies.

The result of the prevailing methods of alternator drive has been the placing on the market of three types of machines: the belted type, the water-wheel type and the engine type.

In the Western Electric Company's belted type, of the smaller capacities, the armature or stator is mounted in a cast-iron frame made of unusual width and stiffness, in order to carry the bearing brackets and resist the twisting moment due to the belt pull. Slide-rails and adjusting screws are provided for belt adjustment. The bearings are supported by brackets attached to the lower half of the armature frame only. Light removable shields are fastened to the upper part of the frame. This construction permits of easy access to the machine and easy removal of the bearing caps.

For larger sizes, the belted type is built with separate base and pedestal bearings; in most cases using three bearings. Slide-rails, similar to those of the bracket type, are used. The smaller water-wheel type is similar to the smaller belted type. The larger capacity is built with separate base and two pedestal bearings. The shaft at one end receives the water-wheel coupling, and at the other end an exciter pulley if such is used.

In the engine-type machine the armature is supported in a cast-iron frame of the deep box girder section. This frame rests at each side on a sole-plate and sub-base. When it is required to slide the armature parallel to the engine shaft, this sub-base is made sufficiently long, and suitable jack-screws are furnished. When the shifting of the frame is not required, the sole-plate is omitted, and the frame rests directly upon the sub-base, which is then made shorter. The rotor, in this type, is mounted directly upon the engine shaft.

Throughout the several types, in constructional details, those types which have been found by experience to be most desirable have been adopted, and, in some cases, new or improved ones introduced.

The cast-iron armature frames are made in one piece for the belted and medium-sized machines; for the larger engine-type machines they are divided horizontally, being secured at the joints by heavy eye-bolts and keys or dowels.
armature frames, to allow for free circulation of air in and around the armature coils and core. In the larger diameters, stiffness is insured by a deep section and large amount of inertia, so that the deflection of the frame, either from its own weight or the unbalanced magnetic pull of an eccentric armature, can not occur.

On the larger machines a copper-strip field is used. The strip is wound on edge and exposes its outer surface to the air, bringing the flat surface of the strip into the best position to resist the strains to which it is subjected.

The rotor construction on the belted and high-speed water-wheel machines is entirely of laminated steel. The poles are built up of thin sheets, in order to minimize the iron losses due to the armature slots. The pole-face is curved to produce a widening gap from the centre of the pole-face outward to distribute the magnetic field so as to generate a sinusoidal electromotive-force wave. The inner end of the pole forms a dovetail or "T" projection which is held in a corresponding slot in the laminated centre by means of double tapered keys. This construction permits of easy removal of the poles for repairs. The field centre is built of heavy laminations, and is homogeneous in structure, and insures uniform strength and good running balance. In the medium-speed machines of the larger sizes the field centre is made of one steel casting, and the laminated poles are dovetailed and keyed in place.

The rotor of the slow-speed and engine-type machines consists of a centre or spider of cast steel, and poles of cast steel bolted to the rim. The pole tips are laminated, and secured by a dovetail to the pole core. The pole-face is curved, the same as mentioned above. The rotor spiders are made solid, and pressed on the shaft in smaller machines of this type, and in the larger capacity the fields may be split.

Carbon brushes are used, several to each collector ring. The collector rings are of a special grade of cast iron.

In the belted and water-wheel machines the shaft is a solid-steel forging, and of large diameter to carry the weight of the revolving field, and resist possible magnetic pull, due to the eccentric wearing of the bearings.

The journals are of ample design for cool running, and are carefully turned and fitted. Special oil grooves are provided in the shaft to prevent creeping and oil throwing, so common in high-speed machines. The bearings are lined with the best quality of babbitt metal, and have from two to four oil rings, according to the size. Large oil wells are provided.

Another Electric Motor Conquest.

New industries are constantly joining the ranks of those operated by electricity. The adaptability, economy and general efficiency of this form of machine driving have led to its installation not only in the more ordinary manufactories but in the less known fields of various classes of work. One of the most recent establishments to adopt this method of drive, is the Archer Daniels Linseed Company, of Minneapolis, Minn. The process of making linseed oil and cake from the raw material is very interesting and the induction motor has been found to adapt itself perfectly to the cycle of operations.

The first step in the process in which the motor has been adopted is at the storage bins. The raw material, flax-seed, is elevated by a thirty horse-power induction motor to the cleaning room. Here, the seed is freed from dust and dirt by motor driven fans, the refuse being sucked up and carried to the waste-bins by exhaust fans driven by the same means. The flax-seed then goes to the grinding mill, the elevator and conveyers being motor driven. The grinder is operated by a sixty horse-power 2,300-volt induction motor, and the seed is reduced to meal of about the fineness of graham flour. The flour is then cooked about an hour and a half in steam jacketed kettles, and the oil is expressed by hydraulic presses, the pumps for which are driven by induction motors. From the presses the oil is pumped first to large vats, then filtered to tanks on a lower level, and again pumped to storage tanks. All these various pumps are driven by induction motors.

The switching and wiring arrangements in this establishment are very complete. All the motors of thirty-five horse-power and over are operated directly at 2,300 volts, the connections being made through three-phase lead-covered cable in iron conduit. Each motor has a controlling panel, and these are grouped on the different floors so that all the motors in one department can be controlled from one point. The central controlling panel is located in the basement which receives the power from the transmission lines at 2,300 volts and distributes it through non-automatic oil switches and expulsion fuses to the various motors in the building. In an annex outside the main building a fifty-six kilowatt, three-phase transformer is installed for supplying current to the 200-volt induction motors of small power. In this same transformer house there is also a twenty-kilowatt single-pole transformer arranged for lighting the building. The current for the transformers is first brought to the main switch-board and then distributed to them through oil switches. From the transformers the wires run directly to the small motor and lighting panels. The complete electrical equipment of this unique plant was furnished by the General Electric Company.

The Derby Gas Company, Derby, Ct., through its engineers, W. S. Barstow & Company, has recently purchased from the General Electric Company two mercury arc rectifier sets. These sets are to be used with the present enclosed direct-current arc lamps, but are so designed that later on they can be used with magnetite arc lamps. Mr. Barstow arranged some time ago with the General Electric Company for a complete installation of mercury arc rectifiers and 1,300 magnetic lamps for the Portland General Electric Company, and these are now in operation.
New Flame Arc Lamps.
The Stanley-G. I. Electric Manufacturing Company, Pittsfield, Mass., has recently placed on the market a flame arc lamp known as the Stanley-G. I. "Brilliant." These lamps are made for either alternating-current or direct-current circuits, both types being of the converging carbon construction, i.e., both carbons feed downward toward each other so as to focus the arc at the same point; thereby eliminating shadows and preventing the formation of non-conducting slag at the carbon tips.

The mechanism of the direct-current lamp is of the differential magnet type, while that of the alternating-current lamp is of the differential disc motor type; the carbons in both cases being regulated by chain feed. Both types are designed, adjusted and carried in stock to burn two in series on 110-volt circuits—standard resistance being furnished with the direct-current and a reactance coil with the alternating-current lamps. All lamps are adjusted for twelve amperes, and an arc voltage of forty-five. Both golden yellow and white light carbons can be used on the direct-current lamps, but golden yellow only will be furnished for the alternating-current lamps.

The weatherproof steel castings, finished in bright japan, are the same for either lamp and are interchangeable. The feeding mechanism is contained in a separate compartment of the case, so carefully partitioned off from the arc that it is unaffected by the heat or loose slag.

Homer Commutators.
The Homer Commutator Company, Cleveland, Ohio, has equipped a complete factory devoted exclusively to the manufacturing of commutators. The company states that this is the only factory in the world devoted exclusively to this line of material. The Homer commutators are manufactured under modern shop methods from pure Lake Superior copper, and of the best insulation that the world's source of supply can furnish. These commutators are the subject of specialized workmanship. Only expert commutator builders who know how to build commutators that are right and stay right, and who have served long years of apprenticeship, are allowed to build the Homer commutators.

The heart of a perfect commutator is the manner in which it fits the shell. An imperfectly fitting commutator is never tight, wears only a short time, and causes all kinds of motor troubles. The Homer commutators, the company claims, are made under the only correct system, the manner in which it fits the shell.

ELECTRICAL REVIEW

The Homer factory is equipped to build anything in the commutator line, from small fan motor commutators to the largest direct-current generator commutators.

The company's sales department is mailing to every street railway in the United States and Canada a monthly commutator bulletin giving valuable information to purchasing agents. Besides quoting prices on all standard street railway motor commutators, it gives the weights and diameters of the wiring surface on all assembled commutators. A large stock is constantly carried, so that immediate shipments are available. The company recently booked an order for an assembled commutator for a Walker 400-kilowatt generator that is over sixty inches in diameter, delivery to be effected in less than three weeks. In addition to this the factory is crowded with orders for commutators for street railway motors, making it necessary to ship over 200 commutators every week.

Copper Production—Increase in the United States.

A table giving an estimate of the production of copper in the various sections of this country compared with the government report of production in 1905 has recently been published. According to this return, the production of copper was increased about eleven per cent over the 1905 output, but the increase in production over the rate of output during the last few months of 1905 is small, if any. The developments of the next few months may change the estimate in the table given herewith.
DOMESTIC AND EXPORT.

MILLION-DOLLAR MICHIGAN ELECTRIC LINE—Articles of incorporation of the Jackson, Ann Arbor & Detroit Electric Railway Company have been filed, the authorized capital being put at $1,500,000, and the company being empowered to secure by purchase or construction a line of railway from Jackson to Detroit, a distance of ninety miles. The incorporators are: W. A. Boland and N. S. Potter, of Jackson; H. R. Corse and Charles W. Osborne, of New York city, and C. M. Booth, of East Orange, N. J.

NEW WISCONSIN ELECTRIC ROAD—D. McAllister, ex-president of the Metropolitan Elevated, of Chicago, Ill., is head of a syndicate that is projecting an interurban electric road from Chicago to Madison, Wis. H. H. Clough is associated with Mr. McAllister in the enterprise. Business men of Madison have been assured that the new line will be completed from Janesville to Madison via Stroutbrough as soon as material and labor can be secured, the financing of the Wisconsin section having been arranged for.

ANOTHER NEW YORK ELECTRIC LINE—The Essex County Traction Company has been incorporated at Albany, N. Y., with a capital of $1,500,000, to construct an electric road forty-one miles long from Westport, on Lake Champlain, to Newman, Essex county, running through Elizabethtown. The principal office is at Ausable Forks. The directors are: Albert L. Washburn, Norman C. Spencer, Wilbur T. Holland, E. S. Goodrich, of Hartford, Ct.; William L. Miley and Thomas D. Trumbull, of Glens Falls, and R. L. Trumbull, of Ausable Forks.

POWER PLANT FOR THE ST. JOSEPH RIVER, ST. JOSEPH, MICH.—A franchise has been granted to Charles A. Chapin, Chicago, Ill., by the St. Joseph (Mich.) board of supervisors for the construction of a dam across the St. Joseph river near Berrien Springs. The work will cost $750,000, and a force of 200 men will be employed for two years to complete the construction. Operations will begin this fall. The Chapin interests are pioneers in water-power business on the St. Joseph river. The company now owns dams and power stations at Penn Island and at Niles and Buchanan.

ORGANIZATION OF THE TWIN STATE GAS AND ELECTRIC COMPANY—The Twin State Gas and Electric Company has been incorporated at Hartford, Ct., with a capitalization of $1,750,000. This company will be controlled by the National Light, Heat and Power Company, of New York. The company has been organized for the specific purpose of taking over and operating twelve electric light companies and railroad plants. These plants are located at Dover, Rochester, Somersworth, Salmon Falls and Hindale, in New Hampshire; Berwick, North Berwick, South Berwick and Lebanon, in Maine, and Brattleboro, Vt.

WYOMING POWER ENTERPRISE—The Asmus Boysen Mining Company has been granted a permit to divert the water of the Big Horn river at Thermopolis, Wyo., for power purposes. The company will erect a reinforced concrete dam which, it is expected, will develop at least 4,000 horse-power. The power is to be used in working the company's mines, which were taken up under special act of Congress opening the Shoshone reservation. It is expected that power will also be furnished to mines owned by other companies on Copper Mountain. The company is considering the advisability of a trolley line from Thermopolis to a connection with the Northwestern Railroad, probably at Shoshone.

NEW ENGLAND INVESTMENT AND SECURITY COMPANY—It is announced that the New England Investment and Security Company, which has taken over the greater part of the trolley roads in Massachusetts formerly owned by the Consolidated Railway Company, a subsidiary company of the New York, New Haven & Hartford Railroad Company, has issued to the Consolidated Railway Company, in payment for its properties, promissory notes and all its preferred and common stock, the outstanding stock issue amounting to $10,000,000 preferred and $10,000,000 common. The Consolidated Railway Company has guaranteed four per cent dividends on the preferred stock and $105 per share in case of liquidation. Under the agreement with the bankers, the Consolidated Railway Company, it is stated, will receive the proceeds of the sale of the common shares in consideration of its affixing its guarantee to the preferred shares.

THE COMMERCIAL CABLE COMPANY, OF CUBA—The certificate of incorporation of the Commercial Cable Company, of Cuba, has been filed at Albany, N. Y. The names of the incorporators are: Clarence H. Mackay, William W. Cook, Albert H. Chandler, Dunmont Clarke, Samuel S. Dickinson, George Clapperton and Albert Beck. These men are also the directors. The Commercial Cable Company, of Cuba, has been organized by the Mackay Company to lay two cables from the United States to Cuba. The monopoly which the Spanish government granted to the Western Union Telegraph Company, forty years ago, expires on December 6, 1906. The plan is to lay two cables from Havana to Key West and thence from Key West to Florida, and to provide special wires from Florida to New York city. The new line will be operated in connection with the Postal Telegraph and Commercial cables, and it is expected that the system will be open for business early in December of this year.

EDUCATIONAL NOTE.

EVENING COURSES AT DREXEL INSTITUTE, PHILADELPHIA—Drexel Institute, Philadelphia, Pa., has prepared a special announcement circular of evening courses in engineering subjects. The institute is endeavoring to meet the needs of young men who can not, for various reasons, undertake a complete day course in engineering. During the coming season complete engineering courses covering four consecutive winters of work are offered. A number of groups have been planned, from which to make selection, each of which leads to a formal certificate granted by the faculty of engineering. The evening courses include engineering drawing, mechanics and heat, elements of chemistry, engineering electricity, advanced engineering electricity, strength of materials and machine design, advanced strength of materials and machine design, thermodynamics and steam engineering, plain surveying, advanced surveying, applied electricity, elementary mechanical engineering, telephony and advanced telephony. The registrar or the director, Arthur J. Rowland, will be pleased to give full information to any one interested in this matter.

DATES AHEAD.

American Street and Interurban Railway Engineering Association; American Street and Interurban Railway Association. Columbus, Ohio, October 15-19.
Old Time Telegraphers' and Historical Society. Washington, D. C., October 5, 9 and 11.
ELECTRIC RAILWAYS.

WEBSTER CITY, IOWA.—The city council has granted a franchise to the Boone, Webster City & Interurban Company, giving a tax exemption of five years.

CONEMAUGH, PA.—The Conemaugh company has granted to the Conemaugh Valley Railroad Company a franchise to lay tracks and erect wires on certain of the town streets.

PEORIA, ILL.—The Alton, Jacksonville & Peoria Railway Company has increased its capital stock from $10,000 to $300,000, notice of increase being filed in both Pekin and Peoria.

WALLA WALLA, WASH.—It is announced that the Walla Walla-Milton interurban electric line will be in operation between Walla Walla and Milton, eleven miles, by December 1.

KANSAS CITY, MO.—The power-house of the Kansas City & Leavenworth Electric Railway, at Wolcott, Kan., burned September 3 with all its machinery. The loss is $300,000.

DAVENPORT, WASH.—A. W. Turner, of Davenport, announces that the line of the Big Bend Transit Company from Spokane into the Big Bend country will be in operation the coming year.

FAYETTEVILLE, W. VA.—The Fayette & Fayetteville Electric Railway Company has closed a contract with T. E. Martin for the erection of an electric power-house at Fayetteville for a proposed railway at a cost of $25,750.

OGDEN, UTAH—A contract has been closed between the Ogden Rapid Transit Company and the Utah Light and Railway Company whereby the latter company furnishes motive power to the transit company for a period of seven years.

FAYETTEVILLE, N. C.—Application has been made to the board of aldermen for a franchise to construct and operate a street-railway system in Fayetteville. The grantees named are: W. D. McNell, J. H. Anderson, John F. Harrison and W. E. Kindley.

SPOKANE, WASH.—D. L. Huntington, general manager of the Washington Water Power Company, has placed an order with the J. G. Brill Company, Philadelphia, for seventeen cars for the Medical Lake and city lines. Delivery is expected the coming fall.

HATTIESBURG, MISS.—President H. L. Camp, of Hattiesburg Light and Traction Company, which company is about to lay a street railway line in Hattiesburg, has given out the route that will be followed by the road. About five miles of track will be put down at once.

FORT ERIE, N. Y.—The Toronto, Niagara & Buffalo Electric Railway has made application to the Fort Erie council for a franchise through the village, the road to be completed in six months. The railway will run to Niagara-on-the-Lake, connecting also with the road to Hamilton and Toronto.

MARTINEZ, CAL.—An electric railroad to connect the town of Black Diamond with the Bowers Rubber Works and the railway stations is the latest project contemplated by C. A. Hooper & Company, of Black Diamond. It is proposed to extend the line from the Bowers plant and the Redwood Manufacturing Company's mill to the town.

GREENVILLE, MISS.—The Greenville & Leland Railroad Company has filed official notice of organization with the authorities of Mississippi. The company plans to build an interurban electric road between Greenville and Leland, and it is said that financial arrangements have already been completed. The company will have $300,000 capital stock.

LOWELL, MASS.—The Lowell & Woburn Street Railway Company has petitioned the Massachusetts railroad commissioners to issue $90,000 additional capital stock to take an equal amount of mortgage bonds of the Lowell & Boston Street Railway Company, the predecessor of this company. The new company's capital stock at present outstanding is $52,500.

PORTSMOUTH, N. H.—The Atlantic Shore Line contemplates building a new electric railroad from South Berwick through North Berwick village, Bauneg Beg to Sanford. A survey has been made, and construction will be commenced as soon as the line from York to Kennebunk is completed. The new road will open up a large territory, including Bauneg Beg Lake.

BATON ROUGE, LA.—M. Osgood Orton, chief engineer and promoter, and H. V. Melly, right-of-way agent, both representing the Baton Rouge-New Orleans Electric Railway Company, are making final preparations for the commencement of work on the proposed line between this city and New Orleans. It is the purpose of the company to begin work about the first of November.

LIMA, OHIO.—The Western Ohio Railway Company will take over the Lima, Findlay & Toledo Traction Company, issuing $400,000 six per cent cumulative preferred stock in exchange for the same amount of preferred of the Lima & Findlay line outstanding. The Western Ohio has for some time owned all the common stock of the other company, and the change will result in an absolute merger.

CUMBERLAND, MD.—The Meyersdale council has revoked the franchise of the Meyersdale & Salisbury Street Railway Company and has granted a franchise to the Maryland & Pennsylvania Street Railway Company, in which C. H. Jennings, of Jennings, Garrett county, Md., is prominently interested. It is proposed to build a line connecting Meyersdale, Somerset, Frostburg, Md., and points in the Meyersdale coal region.

JACKSON, MISS.—Official notice has been received of the organization of the Greenville & Leeland Railroad Company, an electric line that is to traverse a dozen or more miles of Washington county. The road is capitalized at $300,000, and the directors are: J. R. Robertson, W. H. Hunt, Henry Crittenden, Arthur Hider, Alfred Shelds, E. A. Dalton, Morris Rosenstock, Edward Holland, John L. Henron, Nathan Goldstein and W. A. Everman.

WHEELING, W. VA.—The construction of the new Rapid Transit Railway has been perfected, and plans decided upon in regard to the securing of right of way and franchises in order that work may be started this fall and pushed through to completion. Albert Sheneck, of F. Sheneck & Sons, has been elected president, with A. S. List, vice-president, and George Folmar, secretary-treasurer. The directors are: Albert Sheneck, A. S. List, George Folmar, Otto Sheneck and J. V. Braden.

MUSCATINE, IOWA.—The City Railway and Light Company, of Muscatine, has been sold to Child, Hulawit & Company, of Grand Rapids, Mich. The price paid for the exchange of the properties has not been given out, but it is estimated to be in the neighborhood of $500,000. The interests were formerly owned by the Western Gas and Development Company, of Chicago, of which H. W. Hovey, of Muscatine, is president. No local capital will be interested in the new company, Mr. Huttig retiring absolutely.

MACON, GA.—The Macon Railway and Light Company has installed $100,000 worth of new machinery. The apparatus consists of a 2,500-horse-power turbine, a 1,000-horse-power boiler, pumps, condensers and switchboards for controlling the distribution of the current, and the accessories that go with the apparatus mentioned. It is understood that the additional equipment will furnish power enough to run the cars and the lights for years, the expected increase in business being taken into consideration.

ARKANSAS CITY, KAN.—The Kansas-Oklahoma interurban railway, which was to have been built by eastern capitalists, is being revived. The concern which started out to finance the road dropped it because of a lack of funds. Now another company of capitalists has begun buying up the right of way which had been secured by the former concern. Options have also been secured on the present street-car lines in Arkansas City and Winfield. The proposed line extends from Arkansas City to Winfield, Geuda Springs and Chillicochee.

LEXINGTON, KY.—A party of local capitalists, interested in the building of electric roads to connect Lexington with the smaller towns in central Kentucky, recently made a tour of the proposed route to North Middletown, Bourbon county. It is proposed to build a line by way of Cynthiana, and as the citizens of both points are anxious to have the road built, it is likely surveyors will be put to work in the near future. The party was composed of County Judge Bullock, Mayor Combe, John Skain, M. C. Alford,
Major P. P. Johnston, J. W. Rodes, D. F. Frazee, J. W. Porter and
Magistrate Skinner.

ISLIP, N. Y.—James T. Wood, as president of the Cross-Island
Traction Company, has filed with the town board an application
for a franchise to build and operate an electric road, east from the
Brookhaven line, through Bayport and Sayville and north to Lake-
lake and the village of Ronkonkoma. The route is a very circuitous
one, and the application asks for permission to make connection at
several points. The company offers to put up a $10,000 bond
to render the town harmless while the road is being constructed,
and also agrees to strengthen all bridges over which the road passes
and pay one-third of the cost of maintaining the same.

RADFORD, VA.—Pearisburg is to have an electric railroad and
electric lights. The stock has all been subscribed, and the follow-
ing officers have been elected: Charles T. Painter, president; T. J.
Pearson, vice-president; M. P. Farrier, secretary and treasurer; dir-
ector; John S. Crooks, who secured the right of way for the New-
port & Cherokee railroads. John C. Regan, of Des Moines, is vice-presi-
dent; John S. Crooks, Barnard Mason and J. H. Woodrum.
The company will erect a large stone dam at the mouth of Walker's
creek, near Pearisburg, which will furnish many thousand horse-
power for railway, lights and manufacturing establishments. The
electric railroad will extend from the Norfolk & Western station to
the town.

BUFFALO, N. Y.—According to announcements Buffalo and An-
gola will be connected by trolley this fall. J. C. Callish, manager
of the Buffalo Consolidated, states that the contract for construction
has been let to L. E. Myers, of Chicago, and that the line will cost
between $300,000 and $500,000. The road, which will be controlled by
the Sheehan-Mayer interests, will be built along the Hamburg turn-
pike, and will touch all the important intermediate towns. The
Hamburg road will be a portion of the road. Directly after the
completion is expected by the first of the year. It is the ultimate inten-
tion to extend the road on from Jefferson to Brunswick, where it
will intersect the Baltimore & Ohio Railroad, but this latter ex-
tension largely depends upon the attitude of the citizens of Brun-
swick toward the new road.

BOONE, IOWA.—The organization of a company to build an inter-
urban railroad from Boone to Webster City, connecting with the
line from Des Moines to Boone, has been completed, and the new
company will spend about $500,000 in building and equipping the
line. The company is to be known as the Boone-Webster City Inter-
urban Railway Company. The president is E. E. Hughes, who
built the Davenport, Rock Island & Northwestern and the Ozark
& Cherokee railroads. John C. Regan, of Des Moines, is vice-presi-
dent; John S. Crooks, who secured the right of way for the New-
ton & Northwestern, is secretary, and J. H. Herman, cashier of the
First National Bank, of Boone, is treasurer.

EASTON, MD.—The directors of the Peninsula Traction Com-
pany, of Talbot county, which was chartered last fall, have organ-
ized by electing Ernest F. Fink, of Philadelphia, president; Gen-
eral Joseph B. Seth, of Easton, vice-president; Robert A. Orthum,
of Philadelphia, treasurer; Charles R. Wooters, of Easton, secre-
tary. The secretary was authorized to open the books for subscrip-
tions to stock, which is limited to $1,000,000. The first branch of
the road to be constructed will be from a point on Tidghman's Is-
land bordering on the Chesapeake bay through the principal towns
and villages in Talbot, Caroline, Dorchester, Wicomico and Wor-
cester counties, with a terminus at Ocean City, Md. At the time
this road is being constructed a branch will be built, begin-
ning at Cambridge ferry, on the Choptank river, opposite Cam-
bridge, and running from there through Trappe, Hampeldon and
other places connecting with the main line at Easton. After the
construction of these lines a line will be built running from Easton
to Longwood. Wye Mills, Skippton, Centreville, Chestertown and
other towns north of Easton in Talbot, Queen Anne's and Kent
counties, and thence to the cities of Philadelphia and Baltimore.

DENVER, COL.—The Colorado & Southern Railway is consid-
ering the purchase of a reservoir site in Estes park to be utilized
in creating electric power for the operation of some of the pro-
posed electric lines in northern Colorado. Power for the Denver-
Boulder line will be purchased from the Northern Colorado Power
Company, but for the present the Colorado & Southern will make
no more contracts with the concern, but will try to obtain power
from a plant of its own. The Colorado & Southern contemplates
the construction of electric lines as far north as Fort Collins, with
branch lines to Estes park and other points where business is in-
creasing. All the agricultural sections within a radius of twenty
miles of Denver will soon be tapped by electric lines built by the
Colorado & Southern.

AUGUSTA, ME.—Announcement has been made at the office
of the board of railroad commissioners of the granting by the board
of the petition of the Eastern Traction Company, asking the ap-
proval by the board of the location, distances and boundaries of a
proposed street railway from Bangor to Dexter. The road will run
from the city of Bangor through the towns of Hermon,
Levant, Stetson, Exeter, Garland and into the town of Dexter, and
the length of the road will be thirty-five miles. The capital stock
of the corporation is $150,000, divided into 1,800 shares, the par
value of the shares being $100 each. The stockholders, each of
whom owns 200 shares of stock, are as follows: Forest J. Martin,
of Bangor; Charles W. Mullen, of Bangor; Fred T. Dow, of Bangor;
H. Franklin Bailey, of Old Town; Edgar B. Weeks, of Old Town,
and William H. Whitehouse, of Old Town. The directors are:
Forest J. Martin, Fred T. Dow, H. Franklin Bailey and Charles W.
Mullen.

PORTLAND, ME.—Stock has been subscribed for the proposed
electric road from Cumberland Mills to Bridgton via Naples, and
a petition for a charter is now in the hands of the commissioners.
The road is to be known as the Portland & Northern Railroad, and
will engage in a general passenger and freight-carrying business.
The plan is to start the road on Foster street at Cumberland Mills,
nearing the Maine Central Railroad, running thence to Duck Pond,
Westbrook and then to Windham Centre up the Meadow road to
Casco village and thence to Naples village and Bridgton, covering
a route of between thirty and thirty-eight miles. It is proposed to
issue 1,200 shares of stock of the par value of $100, which has
already been subscribed and the majority of it paid into the treas-
ury. The stock has been taken in as cash and the money to be rendered the purchase of a reservoir site in Estes park to be utilized
in creating electric power for the operation of some of the pro-
posed electric lines in northern Colorado. Power for the Denver-
Boulder line will be purchased from the Northern Colorado Power
Company, but for the present the Colorado & Southern will make
no more contracts with the concern, but will try to obtain power
from a plant of its own. The Colorado & Southern contemplates
the construction of electric lines as far north as Fort Collins, with
branch lines to Estes park and other points where business is in-
creasing. All the agricultural sections within a radius of twenty
miles of Denver will soon be tapped by electric lines built by the
Colorado & Southern.

NEW PUBLICATIONS.

PROCEEDINGS OF THE ELEVENTH ANNUAL CONVENTION
OF THE NATIONAL ASSOCIATION OF MANUFACTURERS
OF THE UNITED STATES—The proceedings of the eleventh annual
convention of the National Association of Manufacturers of the
United States have been published. This volume contains the report
of the meeting held in New York city May 14, 15 and 16 of this
year.

THE BALANCED DRAUGHT GAS-PRODUCER FURNACE—
Embry McLean, New York city, has published, in pamphlet form,
a paper entitled "The Balanced Draught Gas-Producer Furnace as Ap-
plied to Steam Boilers," which was read by him recently before the
Brooklyn (N. Y.) Engineers' Club. In this paper the author describes
apparatus designed to produce a perfect combustion of fuel under boilers and gives some figures showing the economies which may thereby be effected.
ELECTRICAL REVIEW

The New York City Railway Company reports for the year ended June 30 as follows: gross, $17,425,660; expenses, $9,576,511; net, $7,849,149; other income, $1,089,938, a total of $8,939,687; charges, $11,225,403, leaving a deficit of $2,286,315.

A gain of $75,000 was made in the gross earnings of the Brooklyn Rapid Transit system during the first eight days of September. The average daily increase was about $9,000, a record gain. The present rate of increase follows daily gains of $2,000 in July and $4,000 in August.

The board of directors of the Western Union Telegraph Company has declared a quarterly dividend of 1¼ per cent upon the capital stock of the company, payable at the office of the treasurer on and after the fifteenth day of October next, to shareholders of record at the close of the transfer books on the twentieth day of September. A special meeting of the stockholders of the company is called for October 10 to authorize an issue of $25,000,000 of redeemable 4 per cent convertible bonds. The bonds will be convertible into stock at not less than par. Of such proposed issue it is intended, subject to the consent of the stockholders, now to issue $10,000,000 of bonds which are to be convertible as mentioned and first to offer the $10,000,000 bonds to the stockholders for subscription pro rata on such terms as may be determined by the board of directors or executive committee. The proceeds of the proposed issue are to provide for the construction of new lines and wires and for the purchase of new property. Since the general consolidation of 1881 and down to June 30, 1906, the company has expended for such purpose the sum of $29,074,646. For the purpose of the special meeting and the annual meeting to be held on the same day the books closed September 20 and will reopen October 12.

The quarterly statement of the Western Union Company for three months ending September 30 (partly estimated) is as follows: net revenue, $2,060,000; bond interest, $322,688, leaving a balance of $1,737,312; dividends, $1,217,022; surplus, $450,290, which, added to the previous surplus of $16,848,728, gives a total surplus of $17,299,018.

Boston: Closing.

American Telephone and Telegraph............. 136½
Edison Electric Illuminating.................. 235
Massachusetts Electric....................... 73
New England Telephone....................... 129
Western Telephone and Telegraph............. 85

Boston Electric issues have been generally firm. It is reported that the buying of both preferred and common stocks has been of the very best character for several months.

Philadelphia: Closing.

Electric Company of America................ 11½
Electric Storage Battery common............ 69
Electric Storage Battery preferred......... 69
Philadelphia Electric........................ 8½
Philadelphia Rapid Transit.................. 85½
United Gas Improvement...................... 38½

The directors of the United Gas Improvement Company have declared a regular quarterly dividend of 2 per cent ($1 per share), payable October 15 to stockholders of record September 29. Books do not close.

Mr. Mack has sold his Philadelphia Rapid Transit holdings, amounting to about 55,000 shares, to Widener interests. The syndicate which bought the stock is composed of George A. Huhn and his associates.

Electric Company of America interests say the earnings continue favorable so far this year, showing some increase since July.

Chicago: Closing.

Chicago Telephone............................ 119
Chicago Edison Light......................... 140
Metropolitan Elevated preferred............. 68½
National Carbon common...................... 38½
National Carbon preferred................... 118
Union Tration common........................ 5
Union Tration preferred..................... 20

The South Side Elevated reports for the year ended June 30, 1906, as follows: gross, $1,771,869; expenses, $1,023,816; net, $748,179; other income, $7,485, a total of $785,664; charges and taxes, $128,441; surplus, $627,223; depreciation, $90,000; balance, $657,223; dividends, $412,953, making the surplus for the year $164,271, which is equal to 5.59 per cent on the $30,323,860 capital stock. The surplus for 1905 was $121,472, and that for the preceding year, $166,664.
TELEPHONE AND TELEGRAPH.

ALBANY, N. Y.—The Hudson River Telephone Company has begun the work of placing its remaining cables under ground.

PARSONS, KAN.—The council passed an ordinance granting the Missouri & Kansas Telephone Company a franchise for twenty years.

CAMDEN, N. J.—After a year's delay the street committee of the Camden city council has decided to accept the proposition of the Bell Telephone Company to place its wires underground.

BELLEVILLE, ILL.—Articles of incorporation of the New Athens & Hecker Telephone Company have been filed at Belleville. Incorporators: William Lischer, John A. Barthel and Philip Wenner.

WATERVILLE, WASH.—The Entiat Telephone and Telegraph Company has been incorporated at Waterville by Frank F. Knapp, D. M. Farris and P. M. Martin, of Entiat, Wash., west of Spokane. The company will operate in the Big Bend country.

NEW YORK, N. Y.—The New York Telephone Company has opened a new building for its Tremont exchange at 178th street and Webster avenue. The telephones in subscribers' stations will at once be changed to the common battery type.

LAWRENCE, MASS.—The Lawrence Automatic Telephone Company has accepted the franchise which was granted by the board of aldermen in July. The promoters of the company say that the work of installing the new system will be started next spring. The surveys will be made this fall.

TEMPLE, TEX.—The Southwestern Telephone Company has a large force of men reconstructing the entire system in Temple. All of the old instruments are being replaced with new ones to be operated under the central energy system. It is estimated that the improvements will cost $50,000.

SPOKANE, WASH.—C. A. Hoag, of Waterville, Wash., and a party of Chelan men have secured a franchise for the construction of a telephone line from Chelan Falls to Lakeside, twenty-five miles west from Spokane. The line will also be built up the Columbia river and will have long-distance connection with the Pacific States line.

CHICAGO, ILL.—By bisecting the Lake View and the West districts, the Chicago Telephone Company is arranging two new districts. On the new stations $500,000 is being spent. The present Lake View district is to be divided at Lawrence avenue to make a new district to be called Edgewater, in which there will be 3,500 telephones. West district will be divided at California avenue.

MONTREAL, CANADA.—The system of the Bell Telephone Company is being extended in all directions in the vicinity of Montreal. New metallic lines have recently been completed from Ste. Agathe to Lac Manicou, Trout Lake and Val Morin. A line has been erected from Lachute to Cushing, and St. Therese has been brought into the trunk lines to come into the Jamaica central office without in-terruption from outside lines and will greatly improve the service in all parts of the old town of Jamaica and more than double the number of connections between Jamaica village and outside points. The work is now being pushed vigorously and it is expected that it will be completed by the middle of October.

OBITUARY NOTES.

MR. CLINTON MANNING BALL died at Rockaway, N. J., on September 10 from paralysis, after a brief illness. He was born October 28, 1843, in Hoscick Falls, N. Y., and was educated in the public schools and at Hamilton College. In his junior year illness compelled him to give up his college career and to travel for a time in Europe. On his return to this country he settled in Utica, N. Y., where he remained until 1879, when he removed to Troy, N. Y., and formed with his brother, John C. Ball, the firm of Ball Brothers, shirt manufacturers. He remained in the firm until 1887, when he went into the electrical business, which he continued until his death. In 1878 he applied for a patent upon an invention which showed all the conditions of the current in the electric arc. Through a faulty claim this invention was thrown out. It is said that at the time of his death Mr. Ball was one of the best authority on magnetic ores in the world.

MR. DANIEL O'DAY, a well-known financier connected with several important electrical enterprises, died in Rouen, France, at the home of one of his daughters, Mrs. S. Triana, last week. Mr. O'Day was born in Kildysart, a small town in Ireland, on February 6, 1844. When very young he came to the United States with his parents, locating in Buffalo, N. Y., where he received his early education, and where he worked until 1865, when he left Buffalo for the oil fields of Pennsylvania. Mr. O'Day was put in charge of the first pipe line for the transporting of oil and petroleum operated by Mr. John D. Rockefeller, who had taken over the South Improvement Company into the Standard Oil Company. Mr. O'Day's rise in the executive department of the Standard Oil Company was rapid from this time forward, and about 1880 he became manager of the company. Mr. O'Day was a member of the New York Athletic Club, the Lotos, Lawyers', Colonial and Catholic clubs. He was connected with the following companies: Atlantic Coast Rail road, president and director; Buffalo General Electric Company, president and director; Buffalo Natural Gas Company, president and director. He was also director in the Buffalo, Tonawanda Islands & Portland Railroad, the Cataract Power and Conduit Company, Federal Trust Company, of Newark; International Railway Company, International Steam Pump Company, Niagara Falls Power Company, Oil City Boiler Works, People's Bank, the Buffalo Sea board National Bank and the Venango Traction and Power Company. He was a trustee of the Colonial Trust Company, the New York Produce Exchange, the Safe Deposit and Storage Company and the Northwestern Ohio Natural Gas Company, of which he was also vice-president, and the National Transit Company.

ENGINEERING SOCIETY.

SCHENECTADY BRANCH, AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS—A meeting of the Schenectady (N. Y.) branch of the American Institute of Electrical Engineers was held at the Alpha Delta Phi fraternity house, Union College campus, on Saturday evening, September 8. The meeting was in the nature of an informal smoker, and plans for the coming season were discussed. Dr. C. P. Steinmetz was the speaker of the evening. There is a promise of great activity, both educationally and socially, among the electrical workers in Schenectady. In addition to the address by Dr. Steinmetz, David B. Rushmore, chairman of the Schenectady branch, made an address and reviewed the prospects for development. A prospectus has been prepared outlining the lecture course for the coming winter. In order to stimulate the interest in these meetings, free trips to New York to attend the monthly meetings of the national association will be given to those who take a conspicuous part in the discussions at the branch meetings. E. B. Merriam, of the General Electric Company, is chairman of the membership committee. A special membership with dues one-half the regular branch dues is proposed for all men employed by the General Electric Company's testing department, the American Locomotive Works' testing department, Union College and the Rensselaer Polytechnic, of Troy.
ELECTRIC LIGHTING.

McEWEN, TENN.—A contract has been closed for an electric light plant for McEwen.

CALUMET, MICH.—The electric light plant at Ontonagon has been placed in operation.

FRANKLIN, MASS.—Local capitalists are considering the establishment of an electric lighting plant.

Baton Rouge, La.—The town council at Jonesville proposes to establish a municipal electric lighting plant.

Paris, Ill.—A new electric light system is to be installed to replace the old one, which has become inadequate.

Emmett, Idaho.—A dam is being constructed at Horsehoe Bend to increase the power output of the electric light system for Franklin.

Franklin, N.Y.—Contracts have been let and work will be begun promptly for the electric light system for Franklin.

Topeka, Kan.—Oberlin is installing an electric light plant in connection with the city waterworks at a cost of $10,000.

Lowell, Mass.—The board of selectmen of Dracut have under consideration the proposition to light the town, by electricity.

Fremont, Neb.—The issue of bonds for the new municipal electric light station has been sold to S. C. Hayes & Son, of Cleveland, Ohio.

Muncie, Ind.—Under the contract recently entered into with the Muncie Electric Light Company, 250 new arc lamps have been installed on the city streets.

Rochester, N.Y.—Charlotte will engage one or more experts to investigate its electric light and water systems before deciding on the question of new plants.

Frankfort, N.Y.—The board of trustees has granted the Hudson River Electric Power Company permission to construct a transmission line through the village.

Watertown, Tenn.—At a recent meeting of the board of mayor and aldermen a franchise was granted to H. H. Weir and W. L. Goodhart to erect an electric light plant in Watertown.

Ottawa, Ohio.—After considerable figures from the Ottawa Electric Light Company for the lighting of Waterworks Park, the village council has decided to install its own lighting plant at the park.

Milwaukee, Wis.—F. W. Boister has taken the contract to build the new power station for the Milo Electric Light and Power Company. Work has begun on the foundation and will be hurried forward as fast as possible.

Flint, Mich.—The new power plant of the recently organized Oak Park Power Company, which will furnish current for the Westin-Mott and Buick factories, is practically completed, and boilers, engines and generators are installed.

Union City, Tenn.—The municipal electric plant at Union City is to be enlarged. Contracts have been let for a new dynamo and engine at a cost of $4,000. The enlargement has been made necessary on account of the increasing demand for service.

Bronson, Mich.—The new electric light plant being built to replace the one recently destroyed by fire is nearly completed. The structure is fifty-two by sixty-four feet, two stories high and constructed of cement blocks. The roof will be of slate, and the whole building practically fireproof.

East Templeton, Mass.—The electric light commissioners have decided to let the contract for the municipal electric lighting plant for the town of Templeton to E. E. Ley & Company, of Springfield, who were the lowest bidders. The work will be started as soon as the material can be procured.

Lyndon, Kan.—Specifications have been issued for the municipal electric light plant to be installed by the city of Lyndon. Bids will be received up to 6 o'clock, September 27. Copies of the specifications may be had by addressing City Clerk J. H. Yearout, Lyndon, or the consulting engineer, M. Dunsworth, Emporia, Kan.

Birmingham, Ala.—At a meeting of the directors of the Coosa River Power Company the following officers were unanimously elected: Roswell H. Cobb, Anniston, Ala., president; H. L. Zell, Birmingham, vice-president; Robert D. Johnston, Birmingham, treasurer; Cyrus H. Kartzell, Pittsburgh, Pa., secretary.

Memphis, Tenn.—The Merchants' Power Company, according to L. G. Van Ness, general superintendent and constructing engineer, will be ready to furnish lights in the uptown district by November 1, and the entire city by next January. Eleven car-loads of machinery, representing about one-third of the equipment, have arrived. This shipment includes two engines of 2,000 horse-power each, and two 500-horse-power boilers.

Mobile, Ala.—A mortgage for $3,000,000 has been filed in the Probate Court, given by the Mobile Electric Company to the American Trust and Savings Bank, of Chicago. It is a forty-year mortgage, bearing five per cent interest. The mortgage covers all the holdings of the company, together with all real estate owned by the concern. The filing of the mortgage is the last act in the consolidation of the lighting interests of Mobile.

Woodbury, Pa.—On November 6 the voters of this city will vote on the question whether or not the city shall construct, maintain and operate a municipal light, heat and power plant. The Public Service Corporation is now furnishing the city with light, and owns an unused plant here. The question of buying this will come up later, if the vote is favorable to the new move. Councilmen believe that there will be a great saving to the taxpayers if they own their plant. Paulsboro will vote on a similar project.

Cortland, N.Y.—The terms for a new lighting contract for five years have been decided upon by the common council and the Cortland County Traction Company. The lamps are to be lighted every night in the year and all night. The contract price is to be twenty-four cents per night per arc, while the price to private consumers is dropped from twelve cents a kilowatt-hour to eleven cents. The price of arc lights under the present contract is twenty-eight and one-half cents per night. Aside from the drop in prices, the traction company is to install new arc lights of the enclosed type.

Rochester, N.Y.—The board of contract at a special meeting awarded the new lighting contract to the Rochester Railway and Light Company. The contract is for five years and under the bid the city will make a saving of more than $305,000 on the old lighting prices. The new contract takes effect July 1 of next year. The bid was at the rate of $57.95 a year for the class of lamps most used. The city is now paying $78.50 a year for these lamps. For double arc lamps on iron poles the company bid $65.96 a year. For single arc lamps on iron poles $68 a year per lamp.

Detroit, Mich.—Desiring to confine to Wayne county the operations of the Peninsular Electric Light Company, now controlled by the Detroit Edison Interests, these interests have formed a new company for the extension of the business of furnishing light and power through the counties of Macomb and St. Clair. The new company will have plants at Royal Oak, and its operations will take in the territory on the Clinton river and in the Anchor Bay territory, possibly extending to the Flats. The new concern is to be known as the St. Clair Edison Company and will have a capital stock of $100,000. The incorporators are Alexander Dow, Hoyt Post and J. V. Oxoby.

Little Falls, N.Y.—The contract to light the streets of Little Falls for a period of five years, commencing January 1, has been awarded by the common council to the Herkimer County Light and Power Company. This is the company that is at present lighting the city at the rate of $45 per lamp per year. Asa, president and manager; Robert R. Zell, Birmingham, vice-president; Robert D. Johnston, Birmingham, treasurer; Cyrus H. Kartzell, Pittsburgh, Pa., secretary.
NEW INCORPORATIONS.

LANSING, MICH.—Lewis Electric Company, Grand Rapids. $6,000.

INDIANAPOLIS, IND.—Evansville & Cannelton Traction Company. $10,500. To operate between the two places.


TOPEKA, KAN.—Lawrence Street Motor Company; $20,000; to extend lines to suburban points. Southwestern Interurban Railway; to build lines connecting Arkansas City, Parsons and Coffeyville.

GUTHRIE, OKLA.—The Hobart Light and Power Company, of Purcell. I. T. $550,000. Incorporators: Frederick A. Gale, of Chicago; George S. Selden, of Erie, Pa.; Dorset Carter, of Purcell; James R. Tolbert, of Hobart, Oklahoma agent.

COLUMBUS, OHIO.—The Oak Point & Elyria Railway. $3,000. To build a line from Elyria to Amherst and thence to Oak Point. Incorporators: E. S. Cook, F. S. McGowan, A. R. Manning, Jr., M. Dickey, and M. L. Fowles, all of Cleveland.


HARRISBURG, PA.—Lawrenceville Street Railway Company, Pittsburgh; $12,000; to build a line from the Pittsburgh subway line at Neville street to Hatfield street, Pittsburgh; directors, Edwin K. Morse, Warner Marshall, Horace W. Baker, Coleman Audel, Pittsburgh, and Harrison M. Williamson, Allegheney. Rebecca Street Railway Company; to build line from Neville street to South Highland avenue, Pittsburgh; same capital and directors.

NEW MANUFACTURING COMPANY.

LOS ANGELES, CAL.—The Electric Heating and Manufacturing Company has purchased land near Dolgeville upon which to erect a plant for the manufacture of heating, lighting and cooking appilances.
THE STANLEY-G. I. ELECTRIC MANUFACTURING COMPANY, Pittsfield, Mass., has issued new literature as follows: bulletin No. 615 describing Stanley-G. I. short-arc lamps. These lamps measure fifteen and one-half inches overall in height and are particularly desirable for use with low ceilings. Circular No. 796 describes Stanley-G. I. sixty-cycle, single-phase induction motors. These motors are built in various sizes from one-quarter horse-power to fifteen horse-power. Circular No. 781 describes the G. I. type "J" primary fuse box or transformer cutout. This device is made up to thirty amperes, 2,500 volts capacity.

THE DE LA VERGNE MACHINE COMPANY, foot East 138th street, New York city, reports the following among other recent orders received for "Hornsby-Akroyd" oil engines: Central New England Railway Company, Hartford, Ct., seven horse-power, geared to primary fuse box or transformer cutout. This device is made up to twenty horse-power, one twenty-horse-power and one thirty-two-horse-power; D. P. Forst & Company, Trenton, N. J., thirteen-horse-power; Webb Wire Works, New Brunswick, N. J., thirty-two-horse-power; J. W. Lippincott, S. P. Scott and Max Meyer, Little Rock, Ark., fifty-horse-power engine to drive a De La Vergne ice-machine.

THE GENERAL ELECTRIC COMPANY, Schenectady, N. Y., has ready for distribution a new series of advertising literature. This includes July indexes to price lists, pamphlets, supply catalogues, descriptive catalogues and fliers. Supply catalogue No. 7,600 gives details concerning controller contact fingers and handles. Price list No. 5,153 gives data concerning Edison "Gem" filament street series incandescent lamps. Flier No. 2,191 describes and illustrates reversing motor-starting rheostats, type R8. Bulletin No. 4,451 describes and illustrates the GE tantalum incandescent lamp; No. 4,452, direct-current series enclosed arc lamps, forms 10 and 11: bulletin No. 4,453, Edison "Gem" high-efficiency incandescent and meridian units; No. 4,454, the GE-60 railroad motor; No. 4,455, single-phase motors, type IS, form KG.

Record of Electrical Patents.

Week of September 11.

830,497. CIRCUIT-CLOSING DEVICE FOR SPEED INDICATORS. Hans Dahl, Berlin, Germany. Filed June 29, 1901. The circuit is closed at a predetermined speed by centrifugal force.


830,568. TROLLEY-CONTROLLING APPARATUS. Frank E. Case, Schenectady, N. Y., assignor to General Electric Company. Filed March 19, 1905. A pneumatic device for raising and lowering the trolley.

830,572. CLAMP FOR ELECTRICAL CONDUCTORS. Scott C. Cutler, Oswego, Ill. Filed July 3, 1905. The jaws are pierced by conical holes, allowing them free movement.

830,573. TELEPHONE SYSTEM. William W. Dean, Chicago, Ill., assignor to Kellogg Switchboard and Supply Company, Chicago, Ill. Filed December 6, 1901. A central battery system, the signals being controlled by a polarized relay.

830,583. COMBINATION TELEPHONE TRANSMITTER AND RECEIVER. Charles C. Gilchrest, New York, N. Y., assignor to Western Electric Company, Chicago, Ill. Filed October 12, 1905. The receiver and transmitter are mounted on one handle, constructed to avoid transmission of vibrations from one to the other.

830,585. INSULATOR FOR TELEGRAPH AND TELEPHONE WIRES. Salathiel V. Graves and Samuel H. McDaniel, McFall, Mo. Filed November 14, 1905. The insulator proper is mounted in a metal box.

830,598. INCANDESCENT LAMP. Gottlob Klumpp and Henry F. Herman, Brooklyn, N. Y.; assigned to Klumpp. Filed September 28, 1905. A de-

830,924. CURRENT RECTIFIER. Franz Pawlowski, Vienna, Austria-Hungary. Filed November 14, 1904. The electrolyte of the rectifier is a hemisulphide of copper.


830,971. ELECTRIC CLOCK. Ulysses L. Collins, St. Louis, Mo. Filed September 18, 1905. A spring-driven, magnetically wound clock.

830,975. APPARATUS FOR PRODUCING HIGHLY OXONIZED AIR OR OXYGEN. Auguste Bachaux, Paris, France, assignor to Wilhelm Mallmann, Ruremonde, Holland. Filed April 28, 1904. The electrode is formed of an inner conducting tube, an intermediate non-conducting and an outer conducting tube, air spaces separating the three.

830,982. SYSTEM OF ELECTRICAL DISTRIBUTION. Justus B. Entz, Philadelphia, Pa. Filed March 28, 1905. A regulator automatically controlling a rotary converter, enabling a storage battery to equalize the load on an alternating-current system.

830,911. RECEIVER HOOK FOR TELEPHONES. Denis Howard, Binghamton, N. Y. Filed January 16, 1906. A number of contacts on the receiver hook indicate the station calling.