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EXPERIMENTS IN IMPACT EXCITATION*

G. W. NASMYTH

THE CHARACTERISTICS OF SHORT ARCS BETWEEN METAL ELECTRODES

The author first reviews briefly the history of "impact excitation," since October, 1906, when Wien published a short account of his experiments. In the same year Lepel began his work on the discharge between metal electrodes. By September, 1907, Lepel's apparatus had been so perfected that he was able to transmit messages and musical tones from Slough to Scheveningen, 160 miles, using an e.m.f. of 440 volts and 1.5 amperes of direct current.

The first public announcement of any of the short spark methods of generating oscillations was made by von Arco in April, 1909. The Telefunken Co. had experimented with Lepel's apparatus early in 1907, but finding it unsatisfactory in its form at that time proceeded to develop its own system. Recently, Prof. W. Peukert has announced the invention of a short spark generator in 1906, for which a patent application was filed February, 1907, prior to either the Lepel or Telefunken Co. applications.

These three short spark generators constitute the chief means at present available for producing high-frequency oscillations of the impact excitation type. In principle the three spark generators have much in common, and experiments and theory dealing with any one will have a measure of value for each of the others. The author's experiments have been made on the Lepel generator. This is the simplest of the three, since it uses direct current instead of alternating, as in the case of the Telefunken generator, and it has no moving parts, as in the case of Peukert's apparatus.

Arc or Spark.—The discharge between the electrodes of all three generators is intermediate in character between the ordinary arc and spark discharges, and in the absence of exact definitions for the two terms it is difficult to decide in which class they should be placed. From the arc point of view, Lepel's generator is a direct-current arc between metal electrodes; the Telefunken arrangement is an alternating-current arc, and Peukert's generator is an arc between relatively rotating electrodes. But in general, when the capacity circuit is connected, the discharge of all three generators becomes discontinuous, and corresponds to a spark-gap. This condition also arises in the Poulsen arc, although to a less extent. Von Arco has suggested the following definitions: "By arc excitation one might understand that method of producing oscillations by which the rate of condenser discharges is equal to or about the frequency of the oscillations; by spark excitations, that method by which this rate is considerably less." This definition makes the type of discharge depend upon the constants of the circuit, and the same generator might be an arc or a spark-gap under different conditions. The author's experiments on the Lepel generator have demonstrated that in many of its general characteristics it bears a marked similarity to the Poulsen arc, and for the present it will be called an arc whenever the applied voltage would be sufficient to maintain the current through the gap if the condenser circuit were disconnected.

*Abstract from *Physical Review*.

Besides the familiar damped discharge of the ordinary spark-gap, three distinct types of arc oscillations have been recognized quite generally by investigators in this field. For convenience the author has named these types after the experimenters who first produced them—viz., Duddell; Poulsen and Wien. The characteristic of the first class of oscillations is that the maximum value of the condenser current is less than that of the direct current through the arc, so that the arc remains lighted. In the second the maximum value of the condenser current is greater than that of the direct current through the arc, so that the arc is extinguished and re-lighted at each oscillation, whilst in the Wien oscillations the maximum value of the condenser current is so great that the arc is not only extinguished, but is re-lighted in the opposite sense. It is with these oscillations that this investigation is chiefly concerned.

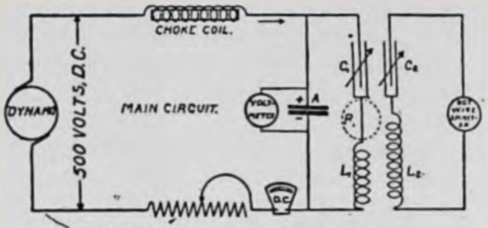


Fig. 1.—Diagram of Connections.

Arrangement of Experimental Apparatus.—In the author's experiments on the Lepel arc the arrangement of apparatus is shown in Fig. 1. The source of e.m.f. was a 500 volt shunt-wound dynamo, direct-connected to a two-phase 900 revolutions per minute induction motor. A large water rheostat made from an old oil barrel, together with two Cutler-Hammer rheostats arranged for connection in series or parallel, each having a maximum resistance of 200 ohms and a current capacity of 1.5 to 2.5 amperes, constituted the resistance in the circuit. The choke coils were two solenoids, each of 0.0296 henry. In the condenser circuit a variable number of Leyden jars, having a capacity of 0.00188 mfd. each, were connected in parallel. A Weston direct-current voltmeter of the d'Arsonval galvanometer type, with a 600-volt and 150-volt scale, was connected across the arc, and a Weston millivoltmeter, with a 5-ampere shunt, was connected in series with the main circuit, as shown. The intensity of the oscillations was measured by an unshunted hot-wire ammeter containing no iron and giving a maximum deflection at 7 amperes of direct current. The position of the ammeter when used for measuring the oscillations is shown by the dotted circle in the primary circuit.

After experimenting with various forms of the Lepel apparatus, it was found that with flat copper plates water cooling of the electrodes was unnecessary, as the radiation to the air was large, and the generator seemed to work better, if anything, as it became heated by the discharge. The author's first experiments were made with brass and copper plates. The results obtained when either metal was used as cathode were fairly satisfactory, but the pitting of the brass plate, due possibly to the volatilization of the zinc, was found to be a source of great annoyance and to make the oscillations inconstant by changing the arc length. Two electrodes of sheet copper ¼ in. thick and 6 in. in diameter were then obtained. These were carefully surfaced in a lathe with a sharp tool set at an acute angle, and were then rubbed with sandpaper and oil. The connecting wires were at first soldered to the copper plates, but after they had been melted off two or three times they were fastened to screws set into the edges of the plates. These electrodes were found very satisfactory. The oscillations are more irregular when the surfaces of the electrodes have been rubbed with emery cloth than when oil and a sandpaper block are used. On the other hand, the vapor of the oil (ordinary machine lubricating oil was used) seemed to have a marked effect in steadying the arc conditions.

Very good electrodes may be made from the hard rolled copper plate used in the photo-engraving processes. The surface of this copper is very smooth and flat, and it holds its shape well on account of its hardness. If this copper sheeting is used, it is unnecessary to turn the plates to a flat surface in a lathe. The plates need only be rubbed with fine pumice stone and oil, and then with a piece of wood carbon and oil, and the surface is almost perfect. Contact with the connecting wires may be made by means of a piece of tin-foil held down by a small weight.

Any kind of paper seems to work well as an insulator and as a source, when disintegrated by the discharge, of the hydrogen and carbon atmosphere which the arc requires for satisfactory working. For the sake of uniformity in conditions, W.S.&B. Paragon typewriter paper in legal size sheets was used in all the quantitative experiments. In thickness this paper is very closely 0.05 mm. per sheet. Mica rings were tried without success, as the discharge occurred either at the edge of the mica, or, if this were prevented, by cutting a sufficiently deep groove in the plates, the discharge took place through the mica instead of across the air-gap. To start the arc various devices may be used, the most convenient one being to short-circuit the arc and then suddenly break the short-circuit with an oil switch, thus bringing the full pressure of the inductive kick of the choke coils to bear on the gap. If the edge of the hole in the paper has been charred, by a match or some other means, the discharge will start as soon as the P.D. is applied.

As in the case of the Poulsen arc, the Lepel generator may be made to give increased power by connecting several arcs in series. By starting the arcs one at a time separately and then connecting them together in series, the author has been able to make as many as three arcs run on 500 volts impressed e.m.f. This was only possible at relatively large currents, however. A better way to obtain increased power at a given impressed e.m.f. is to connect two arcs in parallel, each with its own choke coil and resistance in series.

The method of generating oscillations by connecting arcs in parallel in this way was discovered by the author in 1907, set forth under the title "An Improved Form of the Duddell Singing Arc." Later the attention of the author was called by Mr. Duddell to a lecture given in England before the Institution of Electrical Engineers, in which practically the same principle had been used. The author had overlooked the reference to the earlier work, and is glad to take this opportunity of acknowledging the priority of Duddell in discovering the method of generating oscillations by connecting arcs in parallel.

The characteristic Lepel curve for an arc length of 0.15 mm. when the arc is generating oscillations is shown in Fig. 2. For currents much larger than 4 amperes the arc becomes inactive and the oscillations cease, probably on account of the flatness of the curve for

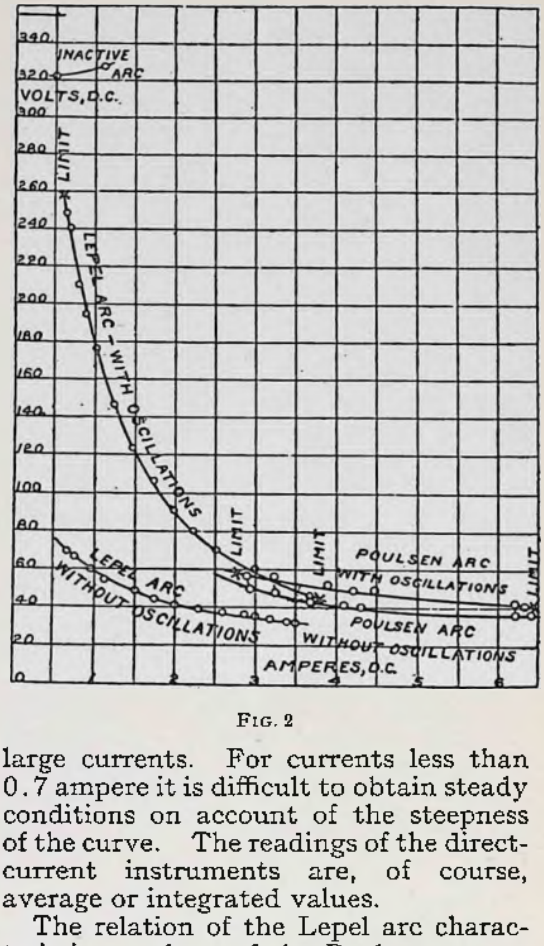


FIG. 2

large currents. For currents less than 0.7 ampere it is difficult to obtain steady conditions on account of the steepness of the curve. The readings of the direct-current instruments are, of course, average or integrated values.

The relation of the Lepel arc characteristics to those of the Poulsen arc are also shown in Fig. 2. The lower curve for the Lepel arc gives the corresponding characteristic when the condenser circuit is disconnected. One reason for the greater effectiveness of the Lepel arc is due to the steepness of the characteristic in the region of small currents in which it operates. Even at larger currents, however, the Lepel characteristic seems to be much steeper than that for the Poulsen arc. The separation of the two curves is also seen to be

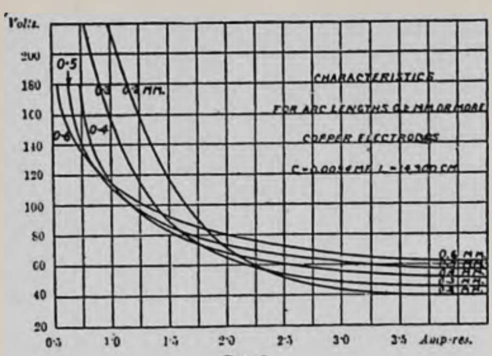


Fig. 3.

much greater than that for the Poulsen arc. The product of the difference of the voltages of the two characteristic by the corresponding amperes may be taken as a measure of the power converted into oscillations. Since the characteristic "without oscillations" varies but little for the different arc lengths, a comparison of the characteristics "with oscillations" will furnish a means of finding the arc length and current which will transform most power into oscillations and give the greater efficiency. It was found that with the author's apparatus the maximum power and efficiency are obtained at an arc length of 0.2 mm. and with a current between 1.0 and 1.5 amperes.

In attempting to find the change in the characteristic curve when the arc length was varied, apparently discordant results were obtained. For large currents of the voltage increased with increasing arc length, as in the case of the Poulsen arc, but for small currents the voltage sometimes increased and sometimes decreased with increase of arc length. It was then decided to make

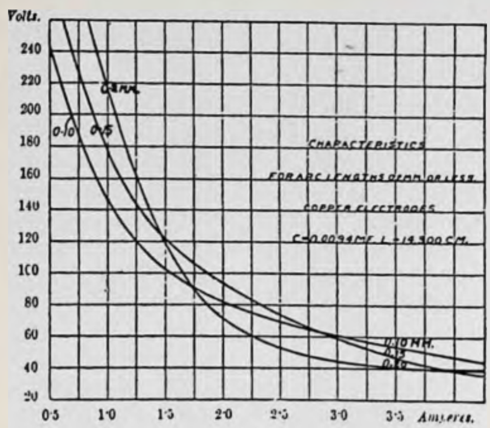


Fig. 4

a systematic exploration of the whole characteristic field, taking a hundred or more observations at each arc length under different conditions and at different times, and drawing a smooth curve through the observations. The results of these experiments are shown in Figs. 3 and 4, representing more than a thousand single observations. It is evident from these curves that for small currents (*e.g.*, 1 ampere) as the arc length is increased from 0.1 mm. to 0.2 mm. the voltage increases; then as the arc length is increased to 0.5 mm. the voltage falls off rapidly at first, then more slowly, and begins to rise again

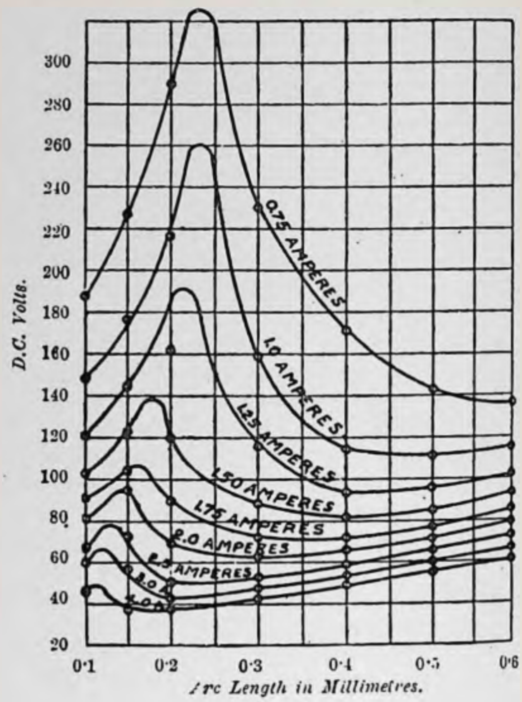
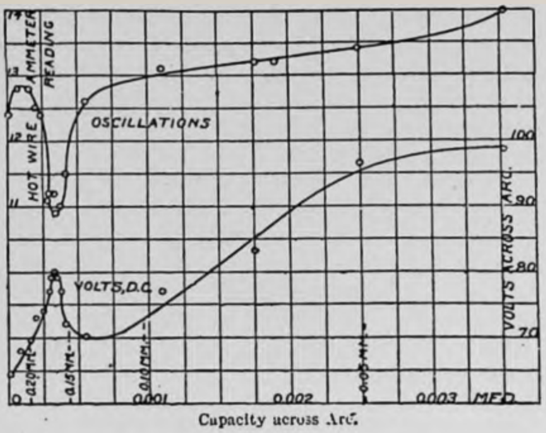


Fig. 5

as the length is increased to 0.6 mm. If cross sections of the curves are taken in this way at constant currents, and the P.D. across the arc plotted against the arc length, the family of curves shown in Fig. 5 is obtained.

This suggested a resonance phenomenon, and tests were at once made to determine whether the effect was a true one corresponding to something inherent in the short spark form of excitation, or a false effect due to some peculiarity in the measuring instruments. The substitution of another voltmeter, and, moreover, its high resistance, precluded



Capacity across Arc.

FIG. 6

the possibility of resonant oscillations through the voltmeter. The clue to the cause of the phenomenon was obtained accidentally, and it was suspected that the curious variations in the arc voltage as the arc length was increased might be due to the change in the capacity of the arc as the distance between the plates was varied. A rough computation, using 1 as the dielectric constant of the paper and gas between the plates, showed that the capacity of the arc varied between rather wide limits, from 0.0016 mfd. at 0.10 mm. arc length to 0.00023 mfd. at 0.70 mm. Accordingly, a variable air condenser was connected directly across the arc, and the values of the arc voltage and oscillation current were read as the capacity in parallel with the arc was varied. The arc length used was 0.25 mm. and the direct-current ammeter reading was maintained constant at 2.5 amperes by varying the resistance in the main circuit. The results are shown in Fig. 6.

In Fig. 6 the variable capacity in parallel with the arc is plotted as abscissa, with the direct-current voltage across the arc and the corresponding intensity of the oscillations indicated by a hot-wire ammeter as ordinates. The capacities corresponding to arc lengths of 0.05, 0.10, 0.15 and 0.20 mm. have been marked, and the left-hand boundary of the figure, with no capacity in parallel, corresponds, of course, to the arc length of 0.25 mm. actually used. The resistances in series with the arcs have not been plotted, but the resistance curve is approximately the reciprocal of the voltage curve.

It is apparent that the voltage curve with varying arc capacity corresponds qualitatively at least with the voltage curve for varying arc length at 2.5 amperes shown in Fig. 5. The maximum in the voltage in Fig. 5 occurs at an arc length less than 0.15 mm., while in Fig. 6 the maximum occurs at a capacity equivalent to an arc length slightly more than 0.15 mm., as calculated. The discrepancy is due in part to the manner in which the plates forming the arc electrodes were arranged in the two experiments. Further experiments showed that the maxima observed in the voltage in Fig. 5 are due chiefly to the changing capacity of the arc itself, as the arc length is varied, and that corresponding to these maxima in the voltage there are minima in the oscillations produced by the arc.

At small capacities the condensers will charge up quickly, the number of discharges per second will be great, and the sparking potential will be low, since the gas will remain ionized to a large extent. The intensity of the oscillations, as measured by a hot-wire ammeter, will be large, and the average direct-current voltmeter reading low, partly on account of the low sparking potential, and partly because the charging time, when the voltmeter reading is obtained, is relatively small compared with the discharging time, when the voltmeter indication should be relatively small. At large capacities, on the other hand, the quantity of energy liberated at each discharge is large, the trains of oscillations will last a long time, and their effective value will be large even though the number of discharges per second is relatively small. A large reading of the hot-wire ammeter should, therefore, be obtained. But the resistance of the arc will be small while the large current is flowing through it, and the time of each discharge is large compared with the time of charge. In this case also, then, the average voltmeter reading will be small. Between these limiting cases a low value of the oscillations may result from a low value of the group frequency, due to high sparking potential, and a low value of effective oscillation current, due to small capacity. The time of charge will be relatively great and the time of discharge relatively small, giving a large value of the average voltmeter reading. The minimum in the oscillations should correspond with a maximum in the voltage, therefore, and this effect is observed in Fig. 6.

The reason for the shift of the maxima into the region of larger arc capacities as the current is increased is clear from this explanation. If the direct current from the generator is increased, the time required to charge the condensers will be decreased. This is the same effect as would be produced by a decrease of capacity. To neutralize this effect the actual capacity would have to be increased, thus restoring things to the same condition. In other words, as the charging current is increased, the maxima should move over into the region of larger capacities or shorter arc lengths, and this is the effect found experimentally.

To test the assumption that the sparking potential required to break down the insulation increased as the arc current was diminished a Braun cathode ray oscillograph was connected across the arc, so that the maximum deflection of the ray by the electromagnetic field measured the maximum instantaneous or sparking potential across the arc. Experiment verified this.

If horizontal sections are taken through the family of curves shown in Figs. 3 and 4, the variation of the current through the arc, as read by the direct-current ammeter, is found to have maximum and minimum values as the arc length is increased while the voltage across the arc is maintained constant. This is chiefly an effect due to the capacity of the arc, and is explained in the same way as the variation in voltage at constant current was explained, the two phenomena being complementary.

An alternative interpretation may be given to the curves if we assume that the voltage across the arc depends not merely upon the direct current through the arc, but rather upon the effective arc current, or the square root of the sum of the squares of the direct current and the oscillatory current. According to this interpretation, when the oscillations are at a minimum, corresponding to a critical value of the capacity of the arc, the effective current through the arc would be small, and the voltage across the arc would rise to a maximum, even though the direct-current ammeter reading is kept constant.

Investigators who have used the ordinary spark-gap as a means of producing high-frequency oscillations have long been familiar with a similar phenomenon. For a given constant applied voltage at the high-tension transformer or induction coil there is a definite spark length which will give a maximum current in all the circuits. It is possible that this effect is due in part to the influence of the capacity of the spark, but it is probable that the variation of the sparking voltage and spark resistance with the spark length plays a much more important part than in the case of the short arc between large electrodes. A more marked effect has been observed by Duddell in the secondary current of an induction coil when a mercury interrupter was used to make and break the primary current. It is probable that the resistance of the spark-gap in Duddell's experiment plays a relatively more important part than in the phenomena of the Lepel arc.

THE INTENSITY OF THE LEPEL ARC OSCILLATIONS AS A FUNCTION OF THE CURRENT, CAPACITY AND INDUCTANCE

It has just been shown that the Lepel generator resembles the arc more closely than the spark-gap, and has, in common with the Duddell and Poulsen arcs, a falling volt-ampere characteristic. Certain curious maxima in the direct-current voltage across the arc were observed as the arc length was varied at constant current, and the cause of these was finally traced to the influence of the capacity of the arc itself, these maxima in the voltage being accompanied by corresponding minima in the intensity of the oscillations.

Intensity of the Oscillations.—Two striking phenomena meet the observer. First, the alternating current, as measured by an unshunted hot-wire ammeter in the condenser circuit, is two or three times greater than the direct current measured by an ammeter in the main circuit. Second, if the direct current in the main circuit is varied, the intensity of the oscillations passes through a well-defined minimum. The value of the direct current at which this minimum in the oscillations occurs depends on the constants of the circuit, increasing when the capacity is increased and decreasing when the inductance is increased. The first characteristic indicates that these oscillations belong to the third class of "Wien" or "impact" oscillations; the second characteristic has interesting consequences in the theory of the relation of the intensity of the oscillations to the other factors of the circuit.

Inasmuch as the frequency of the oscillations varies with the current in the main circuit, the difficulties of calibration at varying frequencies made it impossible to use any kind of an ammeter with a shunt. Accordingly, a special ammeter was constructed without the use of iron, in which the entire current passed through a small copper wire, 0.22 mm. in diameter and about 9.5 cm. long. This ammeter was connected in the oscillation circuit, as shown by the dotted lines in Fig. 1, and calibrated before and after each set of observations by comparison with the direct-current ammeter in the main circuit.

The results of the experiments on the variation in the intensity of the oscillations with the arc current are given in Fig. 7. Each curve corresponds to a definite capacity in the oscillation circuit, one Leyden jar representing a capacity of 0.00188 mfd. The same inductance, 14,400 cm., was used for the nine curves, so that the frequency range was from 324,000 with nine jars capacity to nearly a million with one jar. In each of the curves the oscillations pass through a minimum, well-defined in the curves for the larger capacities, less so at small capacities. These minima move over into the region of larger arc currents as the capacity is increased, following apparently a straight line law. This furnishes additional evidence that the capacity of the arc itself must be considered as connected in parallel with the capacity of the condenser circuit as far as the effect upon the intensity of the oscillations is concerned.

In the Paper the arc currents at which the minima in the oscillations occur are also plotted as ordinates with the corresponding capacities as abscissæ. The resulting curves are seen to be straight lines. As the inductance in the oscillation circuit is increased the slope of these lines is seen to decrease, at first rapidly, then more slowly. The arc current for miminum oscillations is apparently some inverse function of the inductance, and directly proportional to the capacity. At small inductances traces of a second minimum were observed at smaller currents, and at large inductances these secondary minima became more prominent than the others. These secondary minima follow the same straight-line law as the primary minima.

The straight lines of this figure all give an x intercept corresponding to the capacity of the arc itself, considered as a condenser. The mean value of the intercepts was found to be 0.54 Leyden jar, equivalent to 0.01 mfd.

The capacity of the arc is added to the capacity of the condenser circuit as far as the intensity of the oscillations is concerned. But for the frequency of the oscillations the author's experiments (described later) show that the arc acts merely as a resistance, and that its capacity effect does not enter directly. An important corollary of these two observations is that the Lepel arc may be available as a source of very high frequency oscillations whose intensity shall not be too greatly decreased. In other words, with an arc whose capacity is large, it may be possible to produce electric waves shorter than 1 meter, having a mean intensity much greater than that of the short waves produced by a Hertz oscillator.

Theoretical Considerations.—We can obtain some insight into the reason for the minima observed in the intensity of the oscillations, and shown in Fig. 7, with the aid of a formula first derived by M. La Rosa for the maximum value of the oscillatory current. If we write down the energy relations for the condenser circuit for the instant of sparking and for the instant when the condenser current is a maximum, we have

$$\frac{Li^2_{\text{max.}}}{2}=\frac{LI^2}{2}+\frac{Ce^2}{2},$$

where i is the condenser and I the generator current and e the sparking potential of the gap. Solved for the maximum condenser current, the equation becomes

$$i_{max.} = \sqrt{(I^2 + Ce^2/L)}.$$

The four assumptions under which the formula holds have been summarized by Vollmer as follows: (1) At the instant of sparking the condenser current $i = I$, the generator current. (2) The damping loss due to the resistance of the condenser circuit is negligible. (3) The energy produced in the condenser circuit on account of the falling characteristic of the arc during the discharge time T_2 is negligible. (In the Duddell oscillations this is the main source of energy.) (4) The energy $Ce_b^2/2$, stored in the condenser at the instant that the condenser current is a maximum is negligible. (e_b is the P.D. across the arc during the maximum discharge.)

In order that the formula shall hold for the short spark generators it is necessary to assume also: (5) The energy stored in the capacity of the spark-gap itself is negligible.

Theory shows that the assumption (1) is permissible, since for a sufficiently large choke coil in the main circuit the changes in the generator current are very small. The errors introduced by assumptions (2) and (3) tend to neutralize each other. Assumption (4) is unnecessary, as Vollmer has shown, if we use, instead of e^2, the difference of the squares of the sparking potential e and the P.D. across the arc during discharge, e_b. The author's experiments have shown that the capacity of the arc cannot be neglected in the short spark generators, but as a first approximation we may treat the equation as it stands.

If we assume the simplest relation, that the sparking potential is inversely proportional to the generator current, we have $e^2 = k/I^2$ the proportionality factor k being a function of the arc length. For small variations in the arc length it is probable that k may be considered a constant. Using this value of e, the approximate formula becomes

$$i_{max.} = \sqrt{(I^2 + Ck/LI^2)}.$$

At large values of the generator current I the first term under the radical will be of importance and the second term small. For small values of the generator current the second term will be important and the first term small. Under the limiting conditions of very large or very small currents I, therefore, the condenser current maximum $i_{max.}$ will be large, but at intermediate values the condenser current will have a minimum in its initial maximum value and in its corresponding effective value. This is in agreement with the experiments of the author.

We can find the value of the current for which the oscillations will be a minimum by equating the differential $di_{max.}/dI$ to zero. The condition for a minimum is $I^4 = kC/L$, so that the critical current for minimum oscillations should be a function of the capacity and inductance at constant arc length. This also is in agreement so far with the author's experimental results. The experiments show, however, that the critical current is directly proportional to C instead of to the fourth root. The difference may be due in part to the influence of capacity on the relations of the maximum and effective values of the condenser current, and in part to the influence of the frequency, which is a function of the capacity on the sparking potential. The indirect effect of an increase in the capacity in lowering the sparking potential (through the influence of the duration and intensity of the oscillatory current) would also modify the relation between the capacity and arc current for minimum oscillations.

The capacity of the arc is in parallel with the capacity of the condensers and the divided circuit may give rise to the two minima, observed in the oscillations. The effective capacity of the condenser branch of the divided circuit is reduced by the inductance in series, however, and with a large inductance in the condenser circuit the capacity of the arc becomes more important. This is probably the reason why the second minima become more important than the first at the large inductance of 327,500 cm.

Impact Excitation.—The bearing of the minima in the value of the effective and initial maximum condenser current upon the problem of impact excitation is apparent. It is evident that the oscillations will be most quickly damped out when their initial value is least. The average intensity of the oscillations will be least also in this case. To secure the most favorable conditions for impact excitation, therefore, the arc current or arc length should be adjusted to give a minimum in the intensity of the oscillations. If the arc current is varied by means of a rheostat in the main circuit at constant arc length, capacity and inductance, the desired minimum can easily be found with the aid of a hot-wire ammeter.

THE FREQUENCY OF THE LEPEL OSCILLATIONS

Duddell and Poulsen Oscillations.—From theoretical considerations the author has derived a formula for the frequency of the singing arc agreeing closely with all the experimental data which have been published on the Duddell and Poulsen arcs. In its general form this formula is

$$n=\frac{1}{2\pi}\sqrt{\frac{1}{LC}-\frac{(R+dV/dA)^2}{4L^2}},$$

where n is the frequency, L is the inductance, C is the capacity and R the resistance of the oscillatory circuit, and dV/dA is the slope of the volts-amperes characteristic curve. If we take the value for the slope as given by the author's experiments at high frequencies, viz.,—$(c+ld)/A$, where l is the arc length, A the arc current and c and d are constants depending upon the electrodes and the atmosphere in which the arc is formed; and if, further, we neglect c and R, which are usually

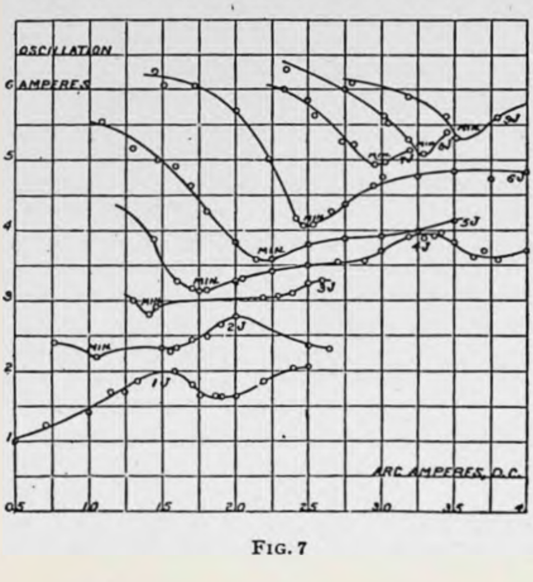


FIG. 7

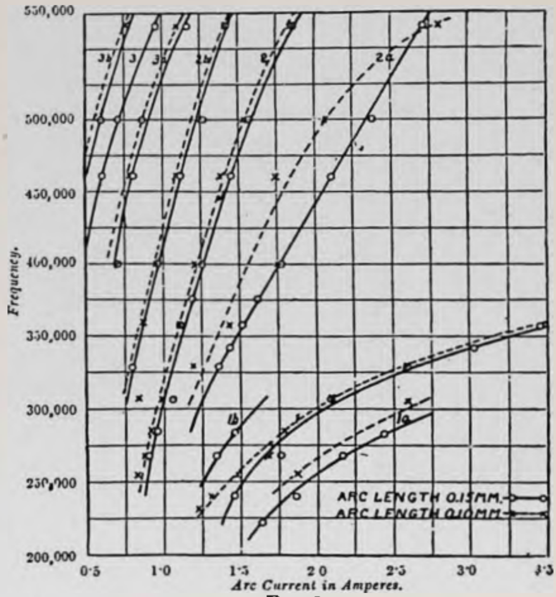


FIG. 8

small in comparison with the term ld, we get the approximate formula

$$n=\frac{1}{2\pi}\sqrt{\frac{1}{LC}-\frac{l^2d^2}{4L^2A^2}}.$$

The law of the variation of the frequency of the singing arc is fairly well known, and may serve as a guide in the investigation of the frequency of the short-arc metal-electrode generators.

Lepel Oscillations.—A loosely-coupled secondary with variable air condensers and a hot-wire ammeter was used to determine the frequency, the connections being the same as in Fig. 1. It was soon found that the frequencies at which resonance could be obtained varied with the arc current. As some of the resonance frequencies were close together, considerable difficulty was experienced in trying to follow the variations of a single one as the current was changed, and it was finally decided to make a complete exploration of the field. The results of the more exhaustive experiments are given in Fig. 8, and show that the frequency of the oscillations produced by the Lepel arc increases with the arc current, as in the singing arc. The curves seem to occur in groups of three, and the middle curves in each group, marked respectively 1, 2 and 3, represent the largest amounts of energy for a given current, the companion curves above and below representing comparatively weak oscillations. Curve 1 is apparently the fundamental, and at large currents of 3 amperes or more this is the only resonance frequency that appears. It approaches asymptotically the frequency given by the Thomson formula $n = 1 / 2\pi\sqrt{L_1C_1}$ as the arc current is increased. The curve 2 is evidently the first harmonic; at 2 amperes, for example, when curve 1 indicates a frequency of 300,000 for the fundamental, the frequency for curve 2 is very closely twice as great, 600,000. The range is not quite large enough to make sure that curve 3 is the next harmonic, but this is probably the case.

The reason for the flatness of the curve 2*a* at 0.15 mm. in the region from about 1.5 to 2.5 amperes is clear from Fig. 5. This showed that the region of maximum voltage at 0.15 mm. is between 1.5 and 2.5 amperes, and Fig. 6 shows that the region of minimum oscillations corresponds with the region of maximum voltage. The currents plotted in Fig. 8 were measured by a direct-current ammeter in the main circuit, whereas the actual current which determines the resistance and characteristics of the arc includes not only this current, but the oscillatory current as well. The effective current traversing the arc is accordingly less, relatively in the region where the full line curve 2*a* is flat, and if total currents through the arc were plotted instead of the direct current the flat part of the curve would bend over into its proper place in the region of smaller currents. The apparent shift of the curve 1*a*, and of most of the points in curve 1, in the same region, is explained in the same way.

Variation with Arc Length.—The full line and dotted line curves for arc lengths of 0.15 mm. and 0.10 mm., given in Fig. 8, show that the frequency decreases with increasing arc length, as in the case of the singing arc and in agreement with the formula above. On attempting to follow the changes in the curve 1 as the arc length was increased apparent inconsistencies were again met with, and the attempt to trace the course of the whole curve 1 was finally abandoned. The variation of the frequency of the fundamental with arc length at a constant current of 2 amperes was investigated. The results are given in Fig. 9.

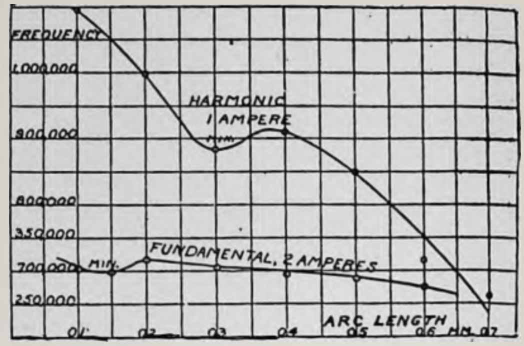


FIG. 9.—VARIATION OF FREQUENCY WITH ARC LENGTH.

In both the curves of Fig. 9, the frequency decreases with increasing arc length except for regions of strongly marked minima in each case. On referring to Fig. 5 again, it is found that these minima correspond to regions of voltage maxima and oscillatory current minima so that the reason for the apparent discrepancies is traced as before to a decrease in the effective current through the arc. Thus, the minima in the oscillations and in the frequency for the 2 amperes direct-current curve both come at 0.15 mm. For the harmonic a smaller capacity and a smaller current were used then for the curves in Fig. 5, and the minimum should be shifted into the region of longer arc lengths or smaller capacities, as it is. If this allowance is made, we may say that the minima in the oscillations and the frequency both come at about 0.3 mm. A second minimum, less pronounced, seems to be indicated at about 0.6 mm. in the curve for the frequency, and it is possible that the corresponding voltage maximum lies just outside the range of Fig. 5.

Proof of the Formula.—It is apparent from the above curves that the frequency of the Lepel arc agrees qualitatively with the formula which has been found to hold true for the singing arc. With the exception of the irregularities due to the oscillation minima the curves are of the same form as the corresponding singing arc curves. A more rigorous test of the formula is obtained by plotting the square of the frequency against the square of the arc length. Both these curves prove to be straight lines outside the regions of the above-mentioned irregularities due to a decrease in the intensity of the oscillatory current through the arc. If the effective current through the arc had been maintained constant instead of the direct current, the agreement of the curves with the straight line requirement of the formula would have been as satisfactory as in the case of the Poulsen arc.

Recent extensive experiments on the Poulsen arc have shown that if the value of $d=k/\sqrt{C}$, where d is the arc constant and C the primary capacity, k has the same value for a given arc for all the values of inductance, capacity and Thomson frequencies used in practice. In its more general form the formula given above thus becomes

$$n=\frac{1}{2\pi}\sqrt{\frac{1}{LC}-\frac{l^2k^2}{4L^2A^2C}}.$$

The effect of capacity on the oscillation intensity and the form of the voltage current characteristics makes it very probable that the more generalized formula holds for the Lepel arc also, but sufficient data for a rigorous test are not yet available.

With a closely-coupled secondary circuit and the arc current arranged to give minimum oscillations, a very sharp resonance curve with only a single wave is obtained by means of a loosely-coupled tertiary circuit, as required by the theory of impact excitation. The maximum shifts with change of arc current, however, leading to the conclusion that the sharp resonance curve of the Lepel arc is due, not to free oscillations, but to *forced undamped* oscillations.

THE ELECTRIFICATION OF CROPS*

After emphasizing the importance of agriculture to the community, and the extreme need there is for this country to take agriculture more seriously, and devote a great deal more of its funds to its development, the lecturer said that the air is always in a state of electrification, and the pointed character of the leaves of plants shows that the electricity is made use of. By artificial means the electrification can be intensified, the plant stimulated, and the action of feeble sunshine assisted. Work in this direction has been done in Sweden, etc., by Lemström, and in France by Berthelot, long ago; but the means available for electrification are but imperfect and feeble. Only recently have we been able to supply electricity of the kind desired in a fairly easy and engineering manner.

"The experiments in which I was myself concerned," said Sir Oliver, "were started some five years ago on a wheat field belonging to Mr. Bomford, with the result of increasing the yield some 30 per cent. I do not say that that rate of increase could be always sustained, and last year the result was not quite so successful as in the preceding years, but by comparison with crops treated in exactly the same way minus electrification there was shown to be a considerable stimulus to plant growth. Gradually these experiments have come to be talked about and attracted a great deal of attention in all parts of the world. My son has devised an apparatus for applying electricity to growing crops in a practical engineering manner, and the Agricultural Electrical Discharge Co., operating on a small scale, has been started at Gloucester, and has already sent out apparatus to many parts of the world—to Germany and Austria, to Java and Sweden, as well as to Scotland for experiments by Mr. Lowe, of Balmakewan, who is testing the whole process scientifically and financially, for a period of five years. Dr. Priestly, of Bristol, a scientific chemist and botanist, is also giving careful attention to the testing of results. I need not say anything about the expense, but it is not great. A 2 h.p. engine is sufficient for a 20-acre plot. It has been found that sugar beet seems to grow more sugary under electrical treatment, and strawberries on Mr. Bomford's farm are brought to maturity earlier and are sweeter. It is principally the tops of plants rather than the roots which appear to be beneficially affected, although leguminous plants seem to be an exception. This and other matters need further experiment."

*Abstract of a lecture delivered by Sir Oliver Lodge, F.R.S., at the Midland Institute, Birmingham, from *The Fruit Grower*.

A UNIQUE LAUNDRY

WALDON FAWCETT

The present policy of economy which has been introduced energetically in the executive departments of our national government under the Taft administration has had as one of its most conspicuous features a reduction in governmental printing bills wherever possible. Decidedly the most ingenious scheme, however, thus far presented for reducing expenses is now being inaugurated by the United States Treasury Department. This is nothing less than a plan for cutting in half the work of printing paper money for the use of the American people. This curtailment of production will be made possible by giving every piece of currency in circulation twice as long an active life as it has heretofore enjoyed, and this latter prolongment is to be accomplished by laundering and thereby rejuvenating the currency when it has become, through repeated handling, unfit for further use.

Under present conditions the United States government prints and puts into circulation each year not less than 220,000,000 bills or pieces of paper money. Of course, this does not mean that there is a continual increase of the volume of money in circulation. On the contrary, that remains virtually stationary in aggregate value. The constant supply of new currency is made necessary by the rapid deterioration of the paper money when in active use, and thus there is maintained a constant rotation of new money going out to circulation and old money returning to the Treasury for redemption and destruction. Under the system heretofore in vogue none of the paper money sent back to the Treasury as unfit for use was reissued, but was destroyed.

While it had been customary to refer to this currency sent back for redemption as "old money," it is not, in most instances, old in the sense that is synonymous with worn-out. Indeed, the average treasury certificate or banknote that comes to the Treasury for retirement had not been in service much more than one year and many of the bills have been in circulation a far shorter time. Now this currency is printed on a good grade of linen paper and the ink is brilliant and permanent, so that the treasury officials in quest of economies recently came to the conclusion that it was nothing short of wanton waste to destroy circulating medium that was not really impaired except in appearance.

A few months ago the Secretary of the Treasury appointed a special committee thoroughly to investigate the whole matter, and this committee, as the result of exhaustive practical experiments, has reported that 90 per cent. of all the currency sent back to the Treasury for redemption can be given a new lease of life by simply washing or laundering the money. As a result of these findings the experimental plant which has been installed at the United States Bureau of Engraving and Printing will be elaborated into a pretentious money laundry, with a capacity for handling thousands of notes per day and effecting for the government a saving in printing bills possibly reaching a total of more than $1,000,000 a year.

The experiments made indicate that the inks with which the bills of high denomination are printed may operate against the successful washing of these bills, but it has been demonstrated that the $1, $2 and $5 bills, which form the great bulk of circulation, can be laundered successfully. Moreover, tests have shown that the laundry process does not in any way impair the strength or other physical characteristics of a piece of currency, and there is no reason why a bill should not be laundered repeatedly. The cost of printing paper money to replace the discarded currency averages $1.35 per one hundred bills. The bills can be laundered at an expense of not more than 1/10 of a cent each, and the government officials are inclined to believe that Uncle Sam can operate at a total expense of $20 per day a money laundry that will freshen up the passé money at the rate of 100,000 bills per day.

Under the process employed the dirty money is first washed with soapsuds formed from a good potash soap, and then, following a rinsing in warm water, is subjected to a bleaching process which, by the way, requires the exercise of considerable care in order that the bills may not be injured. Then the washed money is dried by artificial heat, after which comes what might be termed the "starching" of the money, namely, its passage by machinery through a bath of glue, alum, etc., which supplies "sizing." Finally, the bills are packed between heavy cardboard and "ironed" by a huge press, from which they emerge with all the crisp appearance and the crackle of new-made currency. It may be decided to sterilize the bills in conjunction with the washing, but this is a point on which a definite decision has not been reached.

MINE-RESCUE BREATHING APPARATUS

With the rapid development of mine-rescue work in the United States in the last two years and the increasing use of the mine-breathing apparatus, there has come to the Federal Bureau of Mines a demand for information concerning this apparatus and how it should be properly used. In response the Bureau of Mines has issued Miners' Circular No. 4, on "The Use and Care of Mine-Rescue Breathing Apparatus," by James W. Paul, who has general charge of the rescue work. Mr. Paul makes the statement that the use of such apparatus for rescue work in mines is no longer an experiment, but has become an important factor in lessening loss of life and property from fires and explosions.

The circular describes the various types of apparatus used by the Bureau and gives careful instruction as to the care this apparatus should receive when not in use. Then the author passes upon the qualifications of rescue men at the mines. Mr. Paul says: "Mine men twenty-two to forty-five years old, in good physical condition, who are temperate in their habits and naturally calm and deliberate are best suited for mine-rescue work. Before a man undergoes training in the use of breathing apparatus he should be examined by a physician to ascertain his physical condition, especially the action of his heart and lungs and any defects of the nose or throat. Unless a man has a physician's certificate stating that his physical condition is good, he should not be permitted to take rescue training nor to attempt rescue work in a mine.

"A rescue party should have not less than five, and better not less than six, members. Only such persons should be allowed to join the party as have already been trained in the use of the apparatus and are equipped with rescue apparatus in good order and have agreed to follow the directions of the leader, who must have full charge. While working in unbreathable gases within a mine the men should keep close to one another and not separate under any condition.

"To be efficient and successful a party must take every precaution for its own safety. If one person in a party faints or receives an injury he becomes a burden instead of a help, for the entire party must at once conduct him to the surface or to fresh air. One or two stretchers should always be at hand.

"A relief station or base of operations should be established at the end of the good air and a relief crew with knapsacks should be stationed there, ready to put on their apparatus and start at a moment's notice. A patrol of all brattice and doors leading up to the relief station should be maintained to protect the relief crew from harm.

"At each large mine there should be at least four crews, two outside and two inside crews, each of six men, including a captain and a lieutenant, and these crews should have practice once a week.

"While working in dense smoke the members of a crew should hold a rope which leads to fresh air.

"In case of total failure of an apparatus to supply breathable air, the wearer of the apparatus can throw away all parts but the oxygen cylinder, and breathe from the cylinder through his mouth while endeavoring to reach fresh air with the rest of the crew.

"Apparatus for giving oxygen to one who has been overcome with gases is an essential part of the equipment of a rescue party.

"A telephone helmet is a convenience for shaft work, and its presence lends much confidence to a rescue party. Electric lamps, safety lamps, gas-analysis apparatus, thermometers, a pocket compass, and a map of the mine are necessary parts of the equipment.

"At each training station a record should be kept showing the work done by the men and the difficulties encountered. A record of each apparatus should be kept also. If an apparatus fails to give proper service it should be subjected to the regular tests unless some injury is seen by inspection.

"The United States Bureau of Mines has established a regular course of training in the use of mine-rescue breathing apparatus. This training is designed to give miners or other persons connected with mining a knowledge of breathing apparatus in general, and a confident familiarity with those types of apparatus that are most apt to be used in this country.

"The purpose of the Bureau of Mines in establishing this system of training is to facilitate investigative work within mines in which disasters have occurred, and to make mine owners and miners acquainted with the value of breathing apparatus for rescue operations after mine disasters. It is hoped that, as a result of this work by the Federal Government in the near future, men familiar with such apparatus will be scattered throughout the coal-mining centers of the country, and be available on short notice to assist in rescue operations. After a disaster, valuable time is often lost in training men at the mine before rescue parties can be organized. Furthermore, a man cannot work efficiently unless he has thorough confidence in the apparatus. To give a man this confidence, the course of training has been planned in such a way that he must do work in poisonous or unbreathable gases for periods of one and two hours at a time."

IMPROVISED BATTERY JARS OR CONTAINERS

R. SHIPPER

Many experimenters, especially those experimenting in wireless telegraphy, frequently require a medium-sized battery jar or container for the different batteries in use, condensers or rectifiers, etc., which in the smaller towns and rural districts are not procurable, and when purchased from a distance necessitates a long delay just when wanted.

In the following I will endeavor to describe my mode of procuring these jars, when wanted, one or more as required, at a cost of six cents each:

Purchase as many two-quart fruit jars as required—Ball-Mason jars I have found very suitable. Then rig up a device for cutting the top of same off. All experimenters, no doubt, have a vise of some sort around the premises. This should be fastened to the top of work-bench or table. Then make a jar rest, to insure a perfectly straight cut around the jar, this is done by nailing two pieces of wood about 6 x 8 in. together to form an angle. Place a glass cutter in the vise, laying the jar beside the vise to get the proper cutting angle. Measure 6 in. from the bottom of jar (or any height you wish to make the battery jar) and mark. Place this mark to the wheel of cutter, then nail the jar-rest to the table, letting it rest against the jar cap. Grasp bottom of jar with right hand, and keep left hand on jar cap and the rest, in such a position to let the jar slide between thumb and first finger, yet hold the jar in place. Turn jar to right until you have made a complete circle. Remove the cap from jar and by taking a file or other instrument and tapping, lightly, on inside of jar, directly beneath cut, the top will fly off, leaving you an evenly cut, straight-sided jar of 4½ x 6 in., which is very desirable to the experimenter.

I have had very good success in cutting jars this way, getting nine clean-cut jars out of every ten, the ones which did not crack off straight were generally caused by an air bubble blown in the glass and coming directly in the path of the glass cutter.

UNCLE SAM TO FIGHT NATURE'S ELECTRICITY

E. C. HALL

Most of the comment occasioned by the news that the White House at Washington has just been fitted with a system of lightning protection will be due to surprise that such a reasonable precaution has not been taken before. If any citizen has ever given it a thought, he has doubtless assumed as a matter of course that the official home of the head of the government was long ago equipped with all that is best in the way of lightning protection, especially in view of the fact that the National Weather Bureau has for many years earnestly urged the wisdom of such protection. One excuse for the neglect is that the White House has a metallic roof and rain spouts which run to earth, a system which in itself affords a reasonably good protection from damage by lightning. A tin roof building with water spouts which actually touch the ground is rarely injured by any discharge of atmospheric electricity.

However, had the conditions been known, the people would certainly have demanded that the Chief Executive receive more than "reasonable protection" as given by the tin roof and water spouts of the Executive Mansion. Professor Moore, Chief of the Weather Bureau, speaking with regard to lightning, said:

"Few questions have been so thoroughly discussed from practical as well as theoretical standpoints, as that of the certainty of protection afforded by properly constructed lightning conductors," and Professor McAdie, of the same Bureau, added, "The function of a lightning conductor is two-fold—first, that of conducting the charge to earth; second, the prevention of a disruptive discharge by silent neutralization of the cloud electrification. All high and exposed buildings should be protected by lightning conductors."

Now that the White House has been protected, it is some satisfaction to know that the system employed is the best that scientific research and mechanical skill has so far developed. Lieutenant U. S. Grant, III, Corps of Engineers, and Acting Officer in Charge of the Office of Public Buildings and Grounds, states that "the work was done under specifications prepared by this Office. It consists of a copper cable directly connected to the building by brass fasteners let into the wall and soldered to the tin roof." Similar systems, deriving their greatest efficiency from good construction and simplicity, have been placed on 500 powder magazines, 179 war vessels, 2,000 school houses, 5,000 power plant chimneys, and 25,000 manufacturing plants and public buildings in the United States, besides thousands of residences. The Capitol building at Washington has the same lighting protection system.

The Washington Monument, standing 555 ft. high, on flat, well-watered ground, constitutes an unusually dangerous lightning exposure, and is an excellent illustration of what may be done in the way of protection. It was struck on June 5, 1885, and a committee of scientists was appointed to devise a method of protection. They reported in favor of erecting lightning conductors, and there are now four copper conductors running from the top of the monument into a pit or well 15 ft. below the bottom of the foundations. In this pit there is permanently 2 ft. 8 in. of water. The conductors are connected with each other by means of copper rods (circuit system) and are studded at every 5 ft. of their length with lateral points 3 in. long, gold-plated and tipped with platinum. Since the protective system was put in place, the monument has suffered no damage, although lightning plays about it every time there is a thunder storm. It has been suggested that the monument acts as a huge lightning rod for the entire city of Washington, and this is probably true to a certain degree.

Scientists are free to admit that the phenomenon of lightning is not fully understood, though many facts have been absolutely determined. It is estimated that an ordinary stroke of lightning is of 50,000 h.p. and travels at the rate of 288,000 miles per second. The average electromotive force of a "bolt" of lightning is about 3,500,000 volts;

the current is 14,000,000 amperes, and the time of discharge is about one twenty thousandth of a second. In such a "bolt" there is energy equal to 2,450,000 kw., or 3,284,182 h.p. This enormous force must reach the earth by the path of least resistance, and if an artificial path is offered, it must be a good one.

Carefully compiled statistics show that in the United States between 700 and 800 persons are killed annually and twice that number injured by lightning, while the property loss is not less than $2,000,000 annually. The greatest loss of life, and the greatest property destruction, occurs in rural districts. Electric light and power plants, which in the early days of electricity were particular sources of danger, are now so thoroughly protected that it is rare that such plants are ever damaged by lightning.

Lightning, or, more particularly, a lightning flash, is a discharge of electricity between two electrified bodies, as between one cloud and another, or between a cloud and the earth. While electricity in its commercial form is produced by chemical action or mechanical means, there are also natural means whereby electricity is generated, as, for a simple example, if one rubs his feet over a woolen carpet for some minutes, and then touches his finger to the gas fixtures, a slight spark will pass to the latter with an audible snap, demonstrating the great ease with which the body can receive and dissipate an electrical charge. All substances do not behave in the same manner when an electrical charge has been given them. In some bodies or substances the charge will not permanently reside, and to these is given the name *conductor*. Other substances, having the quality of retaining the charge for some time, or of permitting it to escape very slowly, are known as non-conductors or insulators. At one time it was thought necessary to insulate lightning rods from buildings by glass or porcelain insulators, but that view is not now generally held. An electrical charge suddenly falling upon a conductor, as, for instance, an iron rod, will be safely disposed of, provided the conductor is connected with the earth. If the same charge falls upon a piece of wood or a tree, which are bad conductors, the wood or tree will probably be splintered into fragments, and enough heat may be developed to set fire to the wood.

In nature there are two kinds of electrification, positive and negative. Bodies electrified in the same manner repel one another, while bodies differently electrified, one positively, the other negatively, attract one another. The force exerted in transferring an electrical charge from one point to another depends upon the character of the medium through which it is transmitted. If the medium is a conductor, it will pass from one to the other harmlessly, but if the medium is a non-conductor, as is the atmosphere, a vast increase in energy must take place before the current can pass through the non-conductor, and for this reason artificial conductors must be continuous to the ground. If there is any gap there will be a terrible gathering of energy at the gap. This explains the fact generally observed when a person is struck by lightning, that the shoes are almost always torn from the feet. The air gap between the body and the ground is sufficient to produce the effect described.

Just what causes violent electrical discharges during a thunder storm is a question which has been fiercely debated by scientific men for centuries. Franklin was the first to point out that an electrical field exists in the atmosphere during such a storm. The most recent theory is one put forth by Doctor George C. Simpson, who has proved by laboratory experiments that when a large drop of water is broken up into smaller drops in the air the water becomes positively and the air negatively charged. In other words, when each drop of water is broken up a certain number of units of free negative ions and a less number of free positive ions are released. (An ion is understood to be any extremely small material particle which carries a charge of electricity.) Doctor Simpson therefore formulated the following theory:

"It is exceedingly probable that in all thunder storms ascending currents greater than 18 miles an hour occur. Such currents are the source of large amounts of water which cannot fall through the ascending air. (Drops less than two-tenths in. diameter are carried up, and larger drops are broken.) Hence at the top of the current, where the vertical velocity is reduced on account of the lateral motion of the air, there will be an accumulation of water. This water will be in the form of drops which are continually going through the process of growing from small drops into drops large enough to be broken. Every time a drop breaks a separation of electricity takes place, the water receiving a positive charge and the air a corresponding amount of negative ions. The air carries away the negative ions, but leaves the positive charged water behind.

"A given mass of water may be broken up many times before it falls, and in consequence may obtain a high positive charge. When this water finally reaches the ground it is recognized as positively charged rain. The ions which travel along with the air are rapidly absorbed by the cloud particles, and in time the cloud itself may become highly charged with negative electricity. Now, within a highly electrified cloud, there must be a rapid combination of the water drops, and from it considerable rain will fall; this rain will be negatively charged and under suitable conditions both the charges on the rain and the rate of rainfall will be large."

Whatever may be the origin of the electricity of the air, its effects are well known, and from these effects we may infer that the intensity of the charge in the lightning flash varies between very wide limits, though it is, of course, possible to strike an average. Besides practically harmless flashes of little intensity, and heavy flashes causing great damage, there is a third form of discharge, of a violent, disruptive nature, which is the most dangerous and destructive of all. This is the result of a discharge initiated elsewhere, as when one cloud discharges to another cloud between it and the earth. When this happens, the free charge on the lower or earth side of the cloud nearer the earth will be suddenly relieved and fall upon the earth through previously unstrained air in the most terrible and explosive manner. There is usually little or no warning of this flash.

When a thunder storm develops and moves over the land the air between the earth's surface and the cloud is able at first to resist the passage of a discharge between cloud and earth, but as the electrification increases, the non-conducting quality of the air is overcome and a discharge follows. The danger zone during a thunder storm is approximately the area of the cloud, and within this zone almost any upright object, especially a tree, though possibly not a really good conductor, possibly a bad one, is a better conductor than the air, and is consequently liable to be struck by lightning, the current seeking the path of least resistance to the earth. Therefore, it is a dangerous proceeding to take refuge under a tree, and one should avoid the proximity of chimneys, fireplaces, and wire fences. Wire fences should be grounded at every fifth post, otherwise a deadly current may be carried a long way from the spot where the lightning actually struck. Especially should the fence be grounded if, as is frequently done, the wires are fastened to trees. To ground the fence, attach to the fence post with staples a piece of galvanized wire so that some part of this wire will come into actual mechanical contact with the fence wire and extend thence about 2 ft. into the ground.

The protecting of an ordinary residence, a barn, or other structure not unusually high or exposed, is not nearly so difficult a matter as is generally supposed, and the United States Weather Bureau, in a Farmers' Bulletin published by the Department of Agriculture, has given simple and explicit directions for putting up lightning rods, the expense being comparatively small. Any person of ordinary intelligence and "handiness" can do the work, and the materials can be purchased from any electrical supply house.

If a building has a metallic roof and rain spouts, it may be given reasonable protection from lightning with practically no trouble, it being only necessary to see that the down-spouts are in actual permanent contact with the earth; there should be an unbroken metallic path from the ridge of the roof to the earth.

In providing a ground wire to connect the lower end of a rain spout with naturally and permanently moist earth, a piece of galvanized iron wire (No. 3, about $^{25}/_{100}$ in. diameter is good), a wire cable, or a piece of galvanized pipe may be used. The vital points of the connection are: to reach permanently moist earth, and to secure a perfect metallic joint between the down spout and the earth conductor. If a wire is used it should be flattened out at the end in the form of a tape and then bolted and soldered to the rain spout. The joints should be heavily painted with aluminum paint, and inspected occasionally to see that they are holding. A bad joint may mean serious trouble. If the building has a metallic roof but no rain spouts, wire conductors may be run from each of the corners of the roof, the same care as to making good joints and true ground connections being observed.

This form of protection is effective only on buildings of simple construction —if there are cupolas, etc., terminal wires or rods should be used, all objects higher than the main roof being thus protected. It must be remembered that the longer the run of the wire to earth, the greater will be the resistance to the current, and the larger the wire required. Small wire would be fused by a heavy current, though before fusing it would probably have served its purpose for that one occasion.

If there are gas pipes in the building, the lightning conductors should be kept as far away from them as possible, but, on the contrary, large masses of metal, as water pipes, should be connected to the conductors. The water pipes should be in good connection with the ground.

There has always been much contention as to the liability of certain species of trees to lightning strokes, and in Germany the forest keepers have for many years made careful tables showing the number of trees of each species in certain forests, and the number of each species struck. During a period of eight years it was found that, in forests containing 70 per cent. beech trees; 11 per cent. oaks; 13 per cent. pines, and 6 per cent. firs (*Pinus Silvestris*), 159 oaks were struck, 59 firs, 21 beech trees, 20 pines, 7 larch trees, 5 ash trees, and 4 birch trees. Eliminating the birch, larch and ash trees, which appeared only in small numbers, and taking the liability of the beech to lightning stroke as 1.0, it appears that the liability of the trees to lightning stroke is in the following proportion:

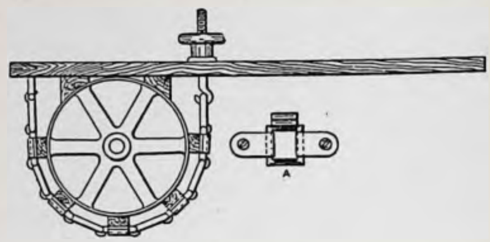
Beech	1.0
Pine	8.1
Fir	64.2
Oak	85.9

This proportion is for one year only, but is regarded as a typical year.

It would certainly appear that the beech is by far the safest tree to plant about the house and farm for shade, and the oak the most dangerous.

Easily Made Prony Brake

This brake is made cheap and is suitable for testing gas engines, etc. The drawing requires but little explanation. The band is made of malleable sprocket chain links of the detachable variety. One of the links to which the wooden



HOME-MADE PRONY BRAKE

blocks are fastened by means of sheet-iron clips and wood screws is shown at *A*. This form of link can be bought for a few cents. It is evident that such a brake band can be easily adjusted to any size pulley or flywheel by taking out or putting in links as required.—*Machinery.*

When Bilkins was away from home on a long business trip, he got a letter from his wife that still puzzles him. It ended thus:

"Baby is well and lots brighter than she used to be. Hoping you are the same, I remain, Your loving wife."

New Reporter: "The auto turned terrapin, and—"

City Editor: "You mean turned turtle."

New Reporter: "Well, it was a high priced machine."—*Judge.*

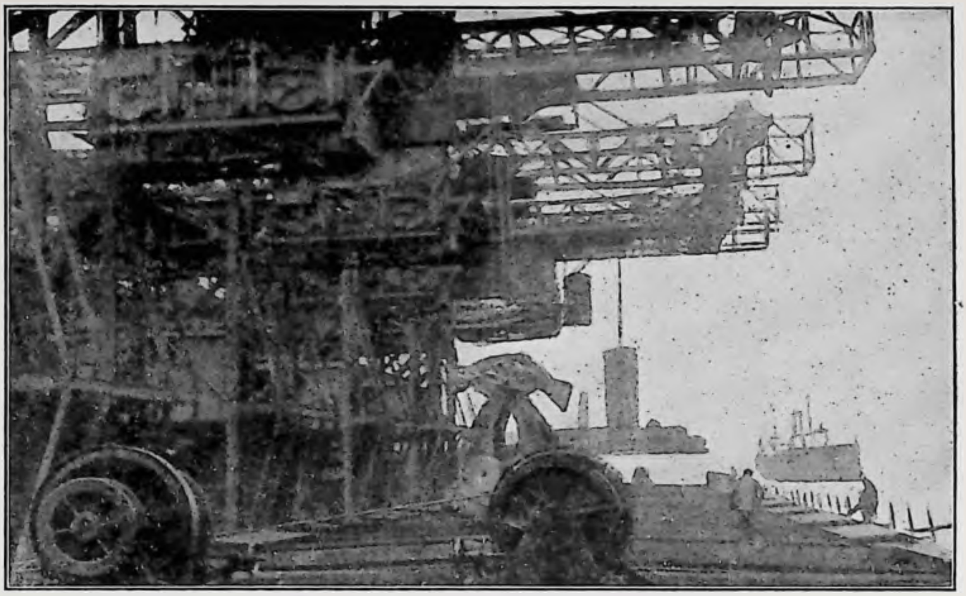
MODERNISM ON THE GREAT LAKES

Until within the last few years, days were required in unloading cargoes of coal that are now handled in as many hours. With the advent of the mammoth steel freighter, machines for the handling of immense cargoes in a minimum time period have been introduced and perfected to keep pace with the rapid development of the craft themselves.

To see a big freighter in the process of loading exemplifies this age of action. In place of the old-time scoop and swivel derrick, a gigantic, electrically-operated machine is now employed that seizes the gondola plus its 50-ton cargo of coal from the track, elevating it high above the ship and dumps its contents into a chute from which the coal pours into the hold. These machines have been so perfected that some of them will load the largest feighter on the Lakes in four or five hours.

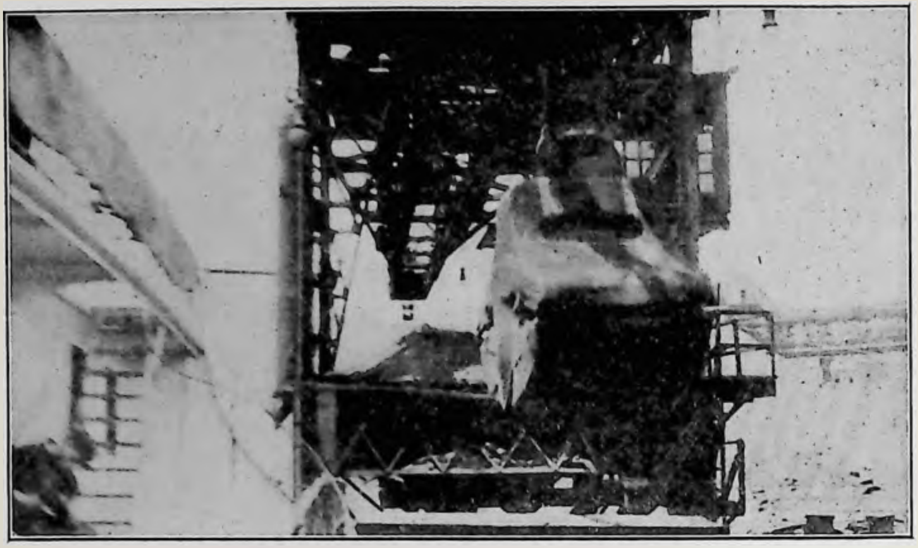
A typical up-to-date unloading machine, or, more accurately, a battery of unloading machines, may be seen at the docks of the Milwaukee Gas and Coke Company, of Milwaukee, Wis. This company, besides producing nearly 1,000,000 tons of coke annually for local consumption, supplies the entire city with artificial gas. Ammonia, tar and light oil (used in explosives) are also extracted in large quantities.

Several years ago cargoes were lightened laboriously by the wheelbarrow method; today electric unloaders are employed. At the docks previously mentioned, several machines are arranged, each above a separate hatch, removing the cargo at the rate of about one scoopful or 75 cu. ft. a minute. The largest freighter on the Lakes, over two city blocks in length, incidentally longer than the world's greatest dreadnaught, may be unloaded in less than a working day.



Unloading machines of the Milwaukee Gas and Coke Company

The scoop upon being filled is carried to the rear of the machine by an overhead truck and the contents dumped into a chute which empties into a U-shaped 6-ply conveyor belt. There are five of these belts, the one illustrated being 600 ft. in length and conveying the discharge from the various machines. At right angles to this belt and directly below its end is another belt which catches the coal as it falls and carries it to another belt, and this to another, and so on. In this manner thousands

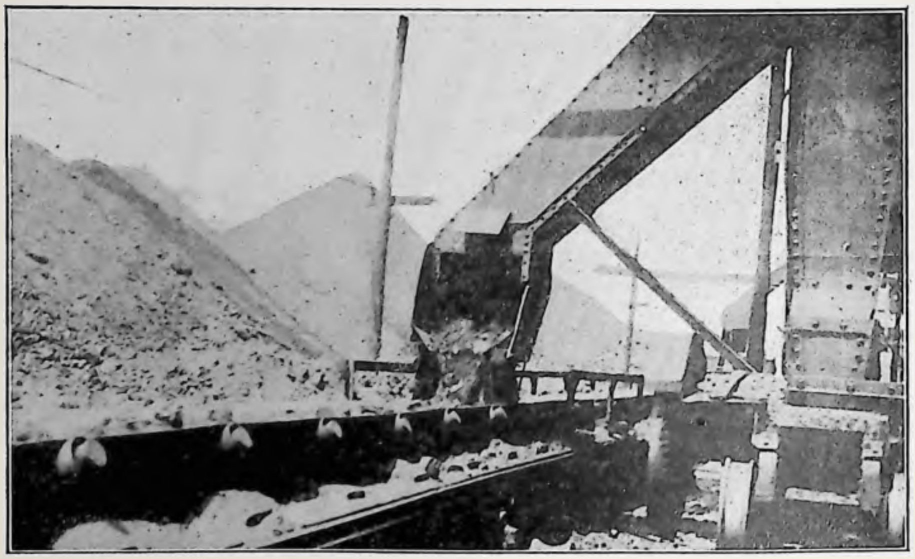


Unloading Scoop

of tons of coal are transported to different parts of the yard and to the furnaces. Five heavy motors are employed in keeping a mile of belting in constant motion.

In mentioning the large ships used in carrying coal, it might be interesting to note that some of the larger and more recent additions to the Great Lakes fleet of over 10,000 vessels have luxuries for the occasional passenger rivalling even those to be found on ocean liners. A few of the more favored craft have electric heaters, ice-making machines, and one vessel even boasts of a large swimming pool, while the majority of later-day ships have electric lighting throughout and intercommunicating telephone systems.

The most modern installation of the United Wireless Telegraph is installed on over one hundred of the boats. This has proven an invaluable asset in the issuing, changing and confirmation of orders, not to mention its primary intention as a safeguard in case of shipwreck. Ships are always in direct communication with some shore station from any part of the Great Lakes both day and night.



Conveyor Belt

STEEL MANUFACTURE REVOLUTIONIZED BY GAS ENGINES

MARC N. GOODNOW

The invention of the gas engine and its perfection in the larger style machines has revolutionized the manufacture of steel in the United States. In these days when every item of cost in manufacturing plays so important a part, invention has come to the rescue and has opened up a field for greater saving than was ever dreamed of before.

The most startling of all changes introduced into steel manufacture has been the substitution of gas engines for steam engines in generating electric power, and it is the substitution of these later methods which has enabled the United States Steel Corporation to produce at its Gary, Ind., plant steel at $2.50 a ton less than at any of its other mills.

While gas engines had been in use at many other plants on a somewhat restricted scale, it was at Gary that they were introduced to displace steam altogether. Except as a sort of match with which to start the machinery and as a safeguard against unseen emergencies, steam practically is an unknown power in the Gary mills. The titanic power required for the operation of the mills comes from gas engines, sixteen of which have been installed, developing a power of 50,000 horse. When the plant has been entirely completed within the next five years it will have fuel for 150,000 h.p. at no cost whatever for the gas and only a slight cost comparatively for the mechanism which converts gas as by-product from blast furnaces and coke ovens.

Never before in the history of the world was such a battery of gas engines constructed as at Gary. One power house, 1,300 ft. in length and 250 ft. in width, has been filled with 3,000 h.p. engines. Another building 600 ft. long contains eight monster machines turning the gas from the furnaces and ovens into power.

The world of industry remarked with misgiving the courage of the steel corporation in entering so boldly into an unexplored field, but from the hour when gas was turned into the tremendous cylinder of the first engine until the present moment results have been of rather an astounding nature. It has been determined from a long series of tests that the gas engines develop two and one-half times as much power as would have been developed in steam engines where this same amount of gas had been consumed by the most scientific appliances known to steel-making.

This gas is what in olden times was allowed to escape into the air, having been unconsumed in the powerful blasts of the blowers. In the great coke region near Pittsburg, where the coke for the Pittsburg mills is made, the volatile matter in the coal, which is driven off to make the coke, goes skyward and is completely lost. At the by-product ovens in Gary, however, this same gas is saved. In the first unit of the coke ovens, which will number 560 and are half completed, 30,000,000 cu. ft. of gas will be made daily. This gas, used in engines specially constructed for it, is estimated to be capable of producing 50,000 h.p. In short, the Gary mills will have 50,000 h.p. 24 hours a day out of what in Pittsburg is allowed to escape from the coke ovens.

In addition to the supply of gas from the coking plant there is an immense amount of gas caught as it comes from the top of the furnace stacks and led through "downcomers" to the cleansing reservoir, in which every particle of dust and dirt will be taken from the gas by washing it with a flow of water, and the cleansed gas is stored in large tanks ready for use in gas engines which furnish the entire power for the operation of the mammoth plant.

The experimental stage of the big gas engines has worn away with their installation and operation by the steel corporation. What further development in power will come from their use in modern industry will be the result of more or less experimental trials by corporations which have the courage to test unknown quantities, as Benjamin Franklin tested electricity, for the sake of handing down to another generation a known, calculable quantity.

THE FUTURE WIRE COMMUNICATION

THEODORE N. VAIL

(*Editor's Note.*—The growth of telegraphic and telephonic communication in the last fifty years has been one of the wonders of this wonderful age. But that growth has been small in comparison with the future growth as predicted by the head of the Bell telephone system and the Western Union Telegraph Company in the following article. Mr. Vail has the broad viewpoint, both from the mechanical and the economic stand. His advocacy of publicity in the management of public service corporations last fall when he assumed charge of the Western Union, has been followed recently, in his annual report to the stockholders of the Bell system, by an even more broad-minded advocacy of the control and regulation of all public utilities by permanent commissions.)

THEODORE N. VAIL
President of American Telephone and Telegraph Co., and President of Western Union Telegraph Co.

We believe that the future development of the wire system in the United States will afford facilities for the annihilation of both time and distance by the general use of electrical transmission for written or personal communication, and will afford electrical communication of every kind of intelligence from everyone at every place to everyone at every other place. It will be comprehensive—universal.

The relations between the telephone and the telegraph system are complementary. The telephone provides something to be used by the public themselves. The telegraph performs a distinct service for the public.

There are two factors which determine the cost of both services—plant cost and operating cost. The total of these costs must be distributed over the actual service performed, and the cost of each item of service, whether telephonic communication or telegraph message, varies directly with the total amount of that service. The more the capacity of the plant in service is utilized, the less the cost of each particular item of service.

Under existing conditions the "telephonic" transmission of written messages cannot take the place of "telegraphic" transmission in the regular conduct of the business.

In a large way the complementary character exists in the joint occupancy and joint use for both purposes of the trunk line plant of both companies.

While the large economies are in the joint occupancy and the joint use of the trunk "wire plant," there are great advantages and large economies in the utilization for both purposes of other plant and operating facilities which must be maintained for a single purpose in any case, and which could bear the additional burden of the service of the other without an additional cost.

To the extent that waste facilities are utilized for public benefit and private profits, just to that extent regular standard service could be cheapened or new service and additional facilities given to the public.

The idea of universality in connection with the telephone system can be broadened and applied to a wire system. To do this efficiently and economically means the combination of every kind of electrical transmission of intelligence into one system, in order that new and additional uses may be developed and that the wire plant and other facilities may be utilized to their fullest extent.

Cheap service comes from full loads. In the wire service this can only be had by employing the plant to its full capacity all the time. In the electrical transmission of intelligence each item of service, the message or telephonic connection, occupies the wires and the time to the exclusion of all else, and the law of increasing returns, therefore, works within the narrow limits of the capacity of the line. There can be no overload.

Cheaper service can only be given by the development of new and additional uses which can be distributed over the time now unused. In the telephone business what can be done in this direction is restricted by the necessity of the personal presence of the parties using the telephone, which limits the use of circuits to certain hours of the day. In the telegraph and cable business, under present conditions, it is different. There is a large capacity unused waiting to be utilized.

Expedited service means a large surplus plant to meet maximum demands, unutilized at other times. The cost of the unutilized facilities must be borne by the expedited service. The result is high charges, due to the small average load with consequent large plant cost.

Under a universal wire system the additional services will be given to the public at rates commensurate with the value of such services, and in the great possibilities of electrical transmission of intelligence, some uses will be found or developed to absorb and utilize this enormous waste and also relieve any congestion now suffered by the more important business, by furnishing a service which would be satisfactory to such of the existing business as has heretofore had no alternative, but would prefer the new service.

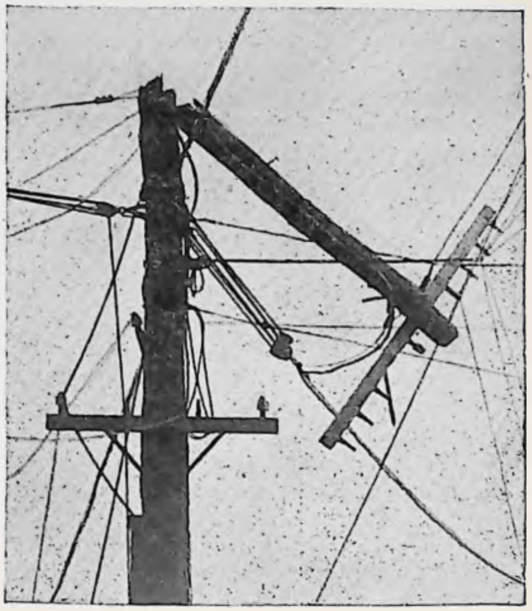
Public control or regulation of public service corporations by permanent commissions, has come and come to stay. Control or regulation exercised through such a body has many advantages over that exercised through regular legislative bodies or committees. Experience has demonstrated that this supervision should stop at control and regulation and not manage, operate nor dictate what the management or operation should be, beyond the requirements of the greatest efficiency and economy.

Such control and regulation can and should stop all abuses of capitalization, of extortion or of overcharges, of unreasonable division of profits.

POLE CUT OFF BY WORMS

The photograph shows a telephone pole on State Street, North Adams, which was cut off recently by worms. Up to the time the pole was found hanging by the guy it was apparently in a sound condition. Without more than the ordinary strain, it broke about 6 ft. from the top and fell over the trolley wire. The worms, or grubs, burrowed directly across the pole, cutting it as straight as though it had been sawed off.

No other part of the pole was damaged in any way. The cable was secured by ropes, the pole removed and a new one erected.—*New England Telephone Topics.*



People who never start things, never finish anything.—*System.*

INCANDESCENT LIGHTING AND LATEST DEVELOPMENTS

EDGAR A. BERGHOLTZ

From the days of our earliest ancestors the problem of artificial lighting has been of the greatest moment to mankind. Various methods have been devised by which this question might be solved. The first attempts were made with various kinds of organic and inorganic substances in a crude way. Later came oil lamps and tallow dips, then gas lights, and finally in the present day the world-wide known electric lamps.

The history of incandescent or glow-lamps begins in the early half of the nineteenth century, for, in 1838, Jobart of Brussels suggested that a small piece of carbon when incandesced in vacuum by an electric current might be used for artificial lighting purposes. As this idea, however, did not materialize until taken up by the great Edison, Jobart cannot be regarded as the successful inventor of incandescent lamps.

In 1841, F. Moleyns of Cheltenham tried to invent an electric lamp of the incandescent type, and obtained more or less successful results by allowing fine coal dust to fall upon a glowing spiral of platinum.

The first notable and practical attempts at producing light in vacuum were perhaps those of J. W. Starr, an American who, in 1845, contrived a platinum lamp which, however, was hardly practicable, because of the complicated structure and the proximity of the fusing and incandescing temperatures of platinum.

Du Moncel, in 1859, aided the progress of incandescent lighting by his rather successful attempts with filaments of carbonized cork and sheepskin.

From this time there seems to have been little progress until 1878, when a great deal of interest was manifested by several note-worthy inventors. This remarkable impetus was due to the increased facilities for constructing lamps. The Sprengel vacuum pump had been recently invented, by which a high vacuum could be created in glass globes containing the filaments; and the dynamo had just been perfected, by which an electric current could be supplied to the public at a cost within range of practical possibility.

In 1878, there appeared in England an incandescent lamp invented by Swan, and was, by far, the most promising hitherto invented. After burning one for two months the inventor exhibited it still in good condition. The filament, which was of excellent quality, was made by first immersing four-inch threads of cotton in a sulphuric acid solution to render them hard and tenacious. These were placed in a crucible containing fine coal dust, and after being hermetically sealed were exposed for several hours to a slowly rising temperature. The remaining carbon wire was then flashed and attached to strips of platinum, and finally set in an evacuated glass globe.

In 1878, there also was produced by two gentlemen, Sawyer and Mann, a lamp whose filament consisted of carbonized paper. In manufacturing this light they made three very important and valuable discoveries: (1) they found that the filament should be arch-shaped; (2) they originated the carbonizing process, by which pure carbon wire is obtained when the filament is incandesced in vacuum to release the occluded gases and then cooled in an atmosphere of nitrogen; (3) for strengthening the carbon wire they invented a method which has now become the "flashing process"—the filament is incandesced in an atmosphere of hydro-carbons, *i.e.*, gasoline vapor, in order to deposit carbon upon it, thereby making it stable, giving it more radiation surface and rendering it more constant and uniform in diameter.

Hitherto the greatest difficulty had been the obtaining of a sufficiently high vacuum with a fair degree of rapidity. This problem, however, was solved by Maxim and Weston in their improvements upon the Geissler evacuating pump which displaced that of Sprengel. As a result of this new type of pump, Edison, with his extensive and thorough knowledge of the properties of carbon, was able to produce in 1879 a carbon lamp, the filament of which consisted of a strip of paper coated with lamp black, and in 1880 a lamp using a filament of bamboo fiber carbonized by heating out of contact with air.

The modern method of manufacturing these filaments is very much improved; chemically pure raw cotton is immersed in a hot concentrated zinc-chloride solution until a viscous mass is obtained, which is squirted through a die with a diameter of that of the desired filament. As the thick liquid comes through it is caught in a vessel containing alcohol. Then it is removed and wound upon a frame 6 or 8 ft. in diameter and left to dry. It is afterwards removed, cut into proper lengths and wound upon blocks of carbon which will give it the shape finally desired. Finally, it is carbonized and flashed, attached to platinum wires and set in evacuated glass globes.

The light given by this lamp is yellow, and its efficiency in most cases is 3.5 watts, that is, it consumes 3.5 watts for every candle power of light produced. However, some special lamps, *e.g.*, sign lamps of the carbon variety, require 5 watts to produce 1 c.p. The normal life of this electric light is 600 to 700 hours, that is, it will burn 600 to 700 hours before its light-giving power decreases 20 per cent.

In 1905 an improvement was made upon carbon filaments by putting them through a hardening process by which their efficiency is increased to 2.5 watts and their normal life to 900–1,000 hours. These lamps are known as the G.E.M. type, *i.e.*, General Electric Metallized.

Another excellent lamp has lately appeared upon the market, *i.e.*, the Helion lamp, manufactured by Parker & Clark. The filament is made by flashing a carbon core in an atmosphere of silicon vapor. As the resistance of such a substance is very high, the filament is consequently immune from the detrimental effects of vibration. Its normal life is about 1,000 hours, and its efficiency is 1 watt. The type is particularly useful where lamps of low candle power are desired.

Though the ordinary carbon lamp has proved very satisfactory in its way, yet, like all inventions, it has its limitations. Its light is yellow and when used constantly has an injurious effect upon the eyes. Again the heat developed by the resistance of the filament tends to volatilize the carbon and when the gas impinges upon the globe, it is suddenly cooled and forms a black deposit upon the glass. The filament, which is otherwise very strong and tough, is in this way weakened and becomes subject to breakage at sudden jarring from mechanical shocks.

In seeking to invent a lamp in which these defects would be absent Walther Nernst made use of a principle discovered about the time of Edison's invention, but hitherto ignored. Certain rare earths, *i.e.*, oxides of thorium, cerium and zirconium, though they offer great resistance to an electric current at ordinary temperature, yet become excellent conductors when heated to 600–700 degrees.

In 1898, Nernst produced an incandescent lamp consisting of three principal parts. The glower, made of rare earths in the shape of a cylinder from .5 to 1 in. in length, is caused to glow by a heater constructed in the shape of a small clay cylinder wrapped with platinum wire which is heated by a current. As soon as the glower reaches the state of incandescence the heater is automatically cut out of circuit and the current passes through the glower only. To prevent "burning out," when the current is subject to variations, Nernst introduced a ballast, the temperature coefficient of which is positive and numerically equal to the negative coefficient of the glower. The former objection to this lamp, *e.g.*, that 30 seconds or more was required for lighting, has been obviated by the introduction of a new type of heater by which the glower is heated in 10 seconds, itself meanwhile emitting light. This lamp is especially commendable for its great efficiency of 1 watt, and also for its white light. Its cost, however, is almost prohibitive.

The appearance of the Nernst lamp gave a new lease of life to inventive genius in the field of incandescent lighting. Hitherto the brilliant results obtained from carbon had acted as a narcotic to all attempts with any other substance. But the product of Nernst's ingenuity awakened the sleeping talent of inventors, and turned their attention to the possibilities of metallic filaments. As a result, attempts were made to discover a metal having a fusing point considerably higher than its incandescing temperature. Such a conductor was found in osmium by Auer von Welsbach, who produced a lamp in 1902. The filament was made of that metal by a process similar to the first tungsten method which is to be described later.

The light emitted by this lamp is most excellent and its efficiency is 1.5 watts. But the cost of lamp, due to the rarity of osmium, is too high for practical use.

Two years later the tantalum lamp, which was invented by Von Bolton, appeared. The filament consists of drawn tantalum wire, which is very tough and very ductile. The difficulty in producing this wire lies in the preparation of the metal for drawing. The pure tantalum is obtained by reducing a tantalum ore; the powder thus obtained is fused in vacuum, the occluded gases being driven off at the same time. The fused mass is then drawn into wires by a process not publicly known, but which, because of the hardness of the metal, must be very difficult. The lamp has an efficiency of 1.8–2.2 watts and gives a brilliant but mellow light. As the filament is ductile, the lamp is especially advantageous for lighting railway and trolley cars and automobiles. The resistance of the wire, however, is not as great as that of carbon, and hence a much longer filament is usually required.

By far the best and most efficient metal filament lamp is the tungsten, another invention of Auer von Welsbach, and introduced in 1905. The metal is obtained principally from wolframite, a tungstate of iron and manganese, and from scheelite, a tungstate of calcium. Out of these ores, is gotten oxide of tungsten, from which, by reduction, pure tungsten is obtained in the form of powder, which is mixed with a suitable organic binder, *e.g.*, amalgam of cadmium and mercury. This mixture is squirted through a die under pressure, and then incandesced in an atmosphere of hydrogen and steam, or of methane, to drive off the cadmium, the mercury and the occluded gases. At the same time the tungsten particles are "sintered" together, that is, they are baked until they cling to one another, but are not fused. The result is a stick of pure tungsten. The metal in this state is very brittle and very fragile, and consequently subject to breakage at sudden jarring. When in the incandescent state, however, tungsten has a slight tendency toward ductility.

The foregoing process of manufacturing tungsten filaments entails such a high cost that the price of lamps until recently has rendered them more or less impractical for common use.

Late in 1910, however, a new method for producing pure tungsten was invented, whereby the metal is rendered more ductile. Tungsten ores are first reduced to the powdered state of pure metal, and then compressed in a mould into sticks ⅜ x 8 in. After the occluded gases have been driven off by incandescing the sticks in an atmosphere of hydrogen, the particles are sintered. This is done by passing through them, for several minutes, an alternating current of about 1,400 amperes, thus raising the temperature almost to fusing point and rendering the solid metal dense and hard.

The sticks are then removed and rolled in a special swaging machine. After prolonged working, they begin to change from a crystalline into a fibrous state, and as a consequence become pliable and ductile. The wire is then drawn by successive processes until the diameter is 1 mil, or less as desired.

The advantages of the tungsten lights are numerous. Their light is almost white, their normal life is about 1,000 hours, and their efficiency at the lowest is 1.25 watts. Of late, this has been improved and raised to 1 watt by the Siemens & Halske Co., of Germany, and in a lamp produced by an electrical concern in Cleveland, called the "Zokul" lamp. The filament which was formerly so delicate and brittle has been improved to such an extent that the lamp can now be used in automobiles and railway cars. Tungsten lamps have also been found excellent for street lighting purposes, and are taking the place of arc lamps in many western cities. It has been found cheaper to install a larger number of them and pay for their maintenance than to retain the old arc lights. In comparing the tungsten lamp with the carbon, it is found that the former emits many more white rays and requires only one third the energy for lighting. The original central station equipment can supply current for three times as many lamps of the tungsten type as of the carbon, and, except for the higher purchasing price of the former, reduces the cost of lighting two-thirds for each lamp.

PHOTOGRAPHING THE MOON

NORMAN BARDEW

There is no other diversion so fascinating as celestial photography. To obtain photographs of stars that are beyond reach of the eye and telescope is truly a charming occupation. But, for the amateur, the moon will probably be the most interesting celestial object to photograph. With the ordinary camera and lens it is impossible to photograph the craters on the moon so that they will be of any size to be appreciated; but, with a small telescope and

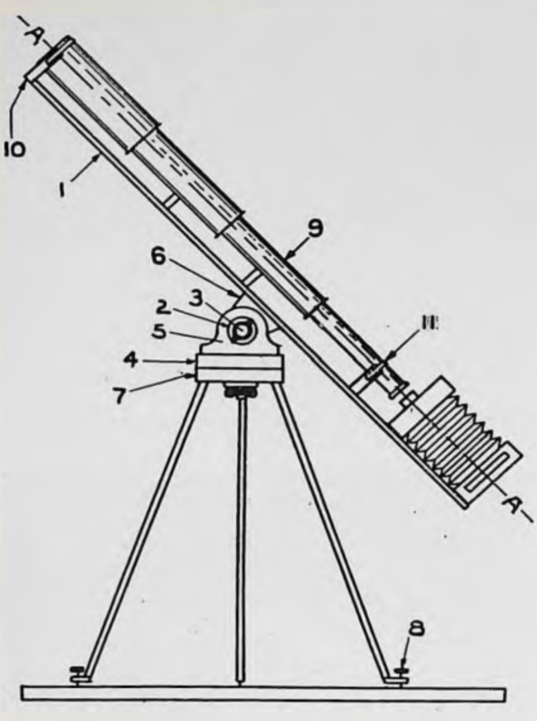


Fig. 1

the proper arrangement it is quite possible to obtain good negatives of the moon throughout all its phases. With the arrangement that is to be described here, well-defined negatives have been taken, as will be seen by the accompanying illustrations. In Fig. 1 is shown the complete arrangement of the apparatus necessary for photographing the moon only. All the apparatus can be made in the home workshop, and no technical knowledge of astronomy is required. The explanation of the figure is as follows:

Piece No. 1 is a light narrow board for holding the telescope and camera body. The camera body is used for the sole purpose of holding the plate holder and shutter. The bearing 2 should work tight and smooth. The axle 3 is made from a ¼ in. bolt and is provided with a large washer at the head end and a washer and thumb nut at the other end. This allows the telescope to be set at any angle very easily. The piece 4 is made round and is rigidly fastened to the piece No. 5. There are two supports 5, one is on each side of 6; 4 is fastened to 7 in the same manner that the bearing 3 was made. If both pieces 4 and 7 are made round, it will greatly add to the appearance of the apparatus. 7 is made from heavy stock as it must support the three legs. For the legs, hickory bars are best to use, as they have very little spring to them. It will be understood that the telescope does not want to be set any higher from the floor or ground than is necessary. If a solid place is to be had, there is no need of having the set screws 8; but if the apparatus is to be set upon the floor, it is best to provide them.

For mounting the telescope 9 to the board 1, two supports are necessary. Both of these, 10 and 11, are made on the same style. They have a half-round groove for the telescope to rest in, and are provided with a brass band or leather strap to fasten the telescope tightly to them. The camera body can be fastened permanently to the board, or it may be fastened temporarily by using brass bands. However, the telescope and camera must be fastened rigidly to the supports and should be on the same optical axis. The dashed line AA in Fig. 1 is the optical axis. The lenses are removed from the camera but not the shutter. The eye-piece and objective of the telescope are left in their places. Now that the complete apparatus has been described, a few words will be said regarding the exposing and finishing of the negatives.

A great deal depends upon the kind of plates that are used. A fast plate will give denser negatives for contact printing, but if enlargements are to be made, a slower, finer-grained plate

Fig. 2. Moon seven days old

should be used. The photograph of the moon, shown in Fig. 2, was taken on a Seed's 27 gilt edge plate. After having decided upon the kind of plate to be used, the developer and fixer should be gotten, so that everything will be in readiness to develop the plate immediately after exposing. The only reason for developing right after exposing is to be able to see what the results are, and so if there are any corrections to be made, they can be attended to before another plate is taken.

The plate is placed in the plate-holder and everything is ready for taking the photograph. The ground glass is put in place, and the lenses of the telescope are wiped off with chamois skin or silk. The image of the moon is brought to a rough focus, and the telescope is set to the proper altitude. Also the apparatus must be set firmly upon the floor or ground. The moon is now sharply focused upon the ground glass by racking the eye-piece back and forth. The plate will generally have to be about 4 or 5 in. from the eye-piece. The image of the moon should be from 1½ in. to 2 in. in diameter. If the image is of the size stated, the exposure will have to be from ¼ to ½ second, according to the kind of plates used. When the moon is focused, move the apparatus so that the image is moved to the right side of the plate. Remove the ground glass and wait until the image has moved upon the plate just far enough so that the edge of the moon is clearing the edge of the field. This can be done by holding the ground glass in a rough position and watching the blurred image of the moon. Just as the image comes into the field, slip the plate-holder in its place and close the shutter; pull the plate cover and expose. After exposing, develop the plate in the usual way, but develop until the details are visible from the back of the plate. Between the developing and fixing, wash the plate thoroughly, so that there will be no danger of stains upon the plate. After fixing, wash for an hour in running water if possible.

The beginner must not be discouraged if he does not make a complete success of obtaining good negatives at first. A dozen plates are sometimes used before a real good negative is taken. This kind of celestial photography will be found pleasurable as well as instructive to all those who try it and make a success of it.

Fig. 3. Moon eighteen days old

SHAFTING—Part II

Materials, Strength and Equipment

DIMENSIONS OF GIB KEYS

In order to keep pulleys, couplings, or clutches from turning on a shaft, either set-screws or keys are employed. The holding power of set-screws is so small in comparison to keys that in nearly all cases of line shafts or head shafts keys are employed in preference to set-screws. They are usually made of mild steel with a shearing strength in the neighborhood of 60,000 lbs. per square inch.

There are two entirely distinct classes or systems of keys, the first and most common being the fastening key with a width of about 1/4 the shaft diameter, and the depth 5/8 to 1/8 of the width. These keys are tapered and set in the keyway all over, and in this way have two functions, that of keeping the keyed-on member from turning on the shaft, also keeping it from having an endwise motion.

The second class of keys fit on the sides only, and are not tapered. They will thus have some clearance in the radial direction and drive by their shearing strength only. The former class of keys, fitting as it does the entire keyway, will act as a strut.

In regard to the proportions of keys authorities differ considerably as to those most practical for the purpose. It may be said, however, that for keys used to drive a shaft or to transmit its entire power in all cases authorities base their proportions upon the diameter of the shaft. For instance E. G. Parkhurst gives the rule that the width of key equals 1/8 the diameter of the shaft, its depth equals 1/6 the diameter of the shaft, and the taper is 1/8 to the foot.

The rule customary in Michigan saw mills is that the keys are of square section, the sides being 1/4 the diameter of the shaft. Unwin gives as the best proportion a width equal to 1/4 the diameter of the shaft plus 1/8 in., thickness equals 1/8 the diameter plus 1/8 in.

These dimensions are all, of course, too high for keys that only transmit a part of the load of the shaft. For all such cases a safe rule is to ascertain the pull of the belt upon the pulley, multiply this by the radius of the pulley, divide the product by the radius of the shaft, divide this again by the length of the pulley hub and by the safe working shearing strength of the key, the quotient will then be the width of the key in inches.

In Table 3 are given the width and thickness of keys for various sized shafts, the key being fitted on all sides, used as standard in the U.S. Navy.

Somewhat different proportion of key is employed where it is deemed necessary to remove the keyed-on member occasionally, also where the key must keep the pulley from an endwise motion. This class of key is known as a gib key, and is illustrated in Fig. 8. Its proportions as given by F. D. Buffum, in *Machinery*, are to have the width 1/4 the diameter of the shaft up to 6 in., above which it is 0.211 times the diameter, taken to the nearest 1/8 in. The gib has a width G, equal approximately to the width of the key, and the height h, also the radius R, equals 1/8 the diameter of the shaft, the minimum value being 3/16 in.

The height of the key equals 1/6 the diameter of the shaft up to 6 in., then it becomes 1/8 the diameter.

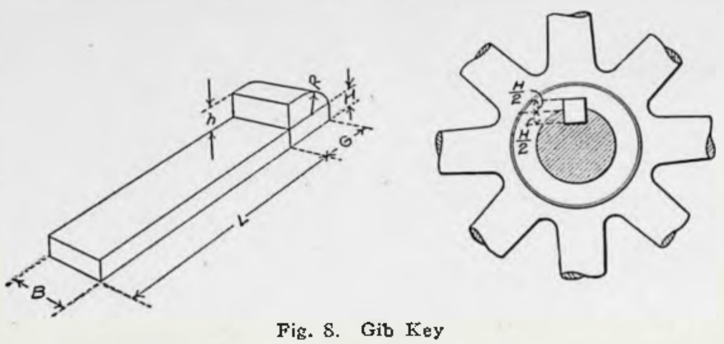


Fig. 8. Gib Key

The length of the key is the length of the hub plus 1/2 in. The taper in this case is the same as given before, that is, 1/8 in. per ft. From these dimensions the accompanying table has been calculated, giving the safe twisting moment on the key per inch of length.

TABLE 3. KEY DIMENSIONS FOR VARIOUS SIZED SHAFTS

SHAFT DIAM. IN.	WIDTH IN	THICKNESS IN	SHAFT DIAM IN	WIDTH IN	THICKNESS IN	SHAFT DIAM IN	WIDTH IN	THICKNESS IN
1/2	5/32	3/16	3 1/4	3/4	7/16	6 3/4	1 3/8	3/4
5/8	1/4	3/16	3 1/2	13/16	7/16	7	1 7/16	13/16
3/4	9/32	3/16	3 3/4	13/16	1/2	7 1/4	1 1/2	13/16
7/8	9/32	7/32	4	7/8	1/2	7 1/2	1 9/16	7/8
1	5/16	7/32	4 1/4	15/16	9/16	7 3/4	1 9/16	7/8
1 1/8	11/32	1/4	4 1/2	1	9/16	8	1 5/8	7/8
1 1/4	3/8	1/4	4 3/4	1	9/16	8 1/4	1 5/8	15/16
1 3/8	3/8	1/4	5	1 1/16	5/8	8 1/2	1 3/4	15/16
1 1/2	13/32	1/4	5 1/4	1 1/8	5/8	8 3/4	1 3/4	15/16
1 3/4	7/16	5/16	3 1/2	1 3/16	5/8	9	1 3/4	1
2	1/2	5/16	5 3/4	1 3/16	11/16	9 1/4	1 7/8	1
2 1/4	9/16	5/16	6	1 1/4	11/16	9 1/2	1 7/8	1 1/16
2 1/2	5/8	3/8	6 1/4	1 5/16	3/4	9 3/4	2	1 1/16
2 3/4	5/8	3/8	6 1/2	1 3/8	3/4	10	2	1 1/16
3	11/16	7/16						

DIMENSIONS OF COLLARS

Feathers or splines, which are keys upon which a sleeve or collar may slide in a direction parallel to the length of the shaft while at the same time compelled to rotate with it, have proportions somewhat different from those given above. It is quite common in this case to place the key on edge, that is, with the greater of the two dimensions in the radial direction of the shaft. The other dimensions are practically the same as given above, except that in this case no taper is used and a driving fit is not employed.

TABLE 4. DIMENSIONS OF GIB KEYS

BORE & SHAFT DIAMETER	WIDTH OF KEY B	HEIGHT OF KEY H	DEPTH KEY SEAT	HEIGHT & RAD. OF GIB.	WIDTH OF GIB G	SAFE TWISTING MOMENT ON KEY PER INCH OF LENGTH FOR S=		
						5000	7,500	10,000
15/16 TO 1 1/8	1/4	3/16	3/32	3/16	1/4	630	940	1,250
1 3/16 TO 1 3/8	3/8	1/4	1/8	3/16	3/8	1,170	1,760	2,340
1 7/16 TO 1 5/8	3/8	1/4	1/8	3/16	3/8	1,410	2,110	2,810
1 11/16 TO 1 7/8	1/2	5/16	5/32	1/4	1/2	2,190	3,280	4,380
1 15/16 TO 2 1/8	1/2	3/8	3/16	1/4	1/2	2,500	3,750	5,000
2 3/16 TO 2 3/8	5/8	3/8	3/16	3/8	5/8	3,520	5,270	7,030
2 7/16 TO 2 5/8	5/8	7/16	7/32	3/8	5/8	3,910	5,860	7,810
2 11/16 TO 2 7/8	3/4	1/2	1/4	3/8	3/4	5,160	7,730	10,313
2 15/16 TO 3 1/8	3/4	1/2	1/4	3/8	3/4	5,620	8,420	11,250
3 3/16 TO 3 3/8	7/8	9/16	9/32	1/2	7/8	7,110	10,660	14,220
3 7/16 TO 3 5/8	7/8	5/8	5/16	1/2	7/8	7,660	11,480	15,310
3 11/16 TO 3 7/8	1	5/8	5/16	1/2	1	9,380	14,060	18,750
3 15/16 TO 4 1/8	1	11/16	11/32	1/2	1	10,000	15,000	20,000
4 3/16 TO 4 3/8	1 1/8	11/16	11/32	5/8	1	11,950	17,930	23,910
4 7/16 TO 4 3/4	1 1/8	3/4	3/8	5/8	1	12,660	18,980	25,310
4 13/16 TO 5 1/4	1 1/4	7/8	7/16	5/8	1 1/4	15,620	23,440	31,250
5 5/16 TO 5 3/4	1 3/8	7/8	7/16	3/4	1 1/4	18,910	28,360	37,810
5 13/16 TO 6 1/4	1 1/2	1	1/2	3/4	1 1/2	22,500	33,750	45,000
6 5/16 TO 6 3/4	1 1/2	1	1/2	7/8	1 1/2	24,380	36,560	48,750
6 13/16 TO 7 1/4	1 1/2	1	1/2	7/8	1 3/4	26,250	39,380	52,500
7 5/16 TO 7 3/4	1 5/8	1	1/2	1	1 3/4	30,470	45,700	60,940
7 13/16 TO 8 3/4	1 3/4	1 1/8	9/16	1	2	36,090	54,140	72,190
8 13/16 TO 9 3/4	2	1 1/4	5/8	1 1/8	2	46,250	69,380	92,500
9 13/16 TO 10 3/4	2 1/4	1 1/2	3/4	1 1/4	2	57,660	86,480	115,320
10 13/16 TO 11 3/4	2 1/2	1 1/2	3/4	1 1/4	2	70,310	105,470	140,630
11 13/16 TO 12 3/4	2 1/2	1 1/2	3/4	1 1/4	2	76,560	114,840	153,130

There are, in addition to the forms mentioned above, various other styles of keys used, such as the Woodruff shown in Fig. 9A, or those fitting into an angle keyway, Fig. 9B, also round keys and so forth. These, however, are of so little use today that their consideration in this article is omitted.

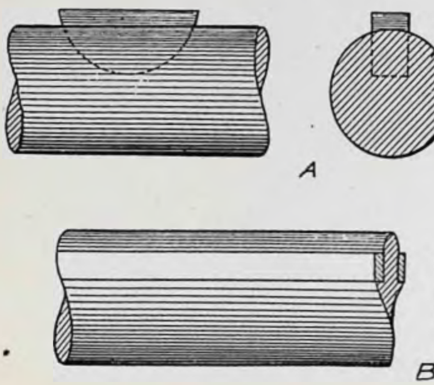
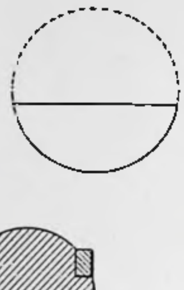


Fig. 9. Forms of Woodruff and Angle Keys

COLLARS

To keep a line shaft from having too much end play it is common practice to employ a collar at each end near a bearing, giving sufficient room for end play of the shaft to keep it from spoiling the bearings, but preventing this from



becoming so large as to throw belts off. In many cases this same effect is accomplished by placing a belt pulley near a bearing and letting the hub act as a collar. This, however, is not always advisable, as the bearing is apt to throw oil upon the belt, causing it to deteriorate rapidly, and also increasing the belt slip.

TABLE 5. DIMENSIONS OF COLLARS

BORE	B	D	H	L	M	S	T
1 7/16	1 5/8	2 3/4	7/8	17/32	3/16	3/8	1/4
1 9/16	1 3/4	3	7/8	19/32	3/16	3/8	1/4
1 11/16	1 7/8	3 1/4	1	19/32	1/4	1/2	5/16
1 15/16	2	3 5/8	1 1/4	19/32	5/16	5/8	3/8
2 3/16	2 1/8	4	1 1/4	21/32	5/16	5/8	3/8
2 7/16	2 1/4	4 3/8	1 1/4	23/32	5/16	5/8	3/8
2 11/16	2 1/2	4 3/4	1 1/2	23/32	3/8	3/4	7/16
2 15/16	2 5/8	5 1/4	1 1/2	27/32	3/8	3/4	7/16
3 3/16	2 3/4	5 3/4	1 1/2	1	3/8	3/4	7/16
3 7/16	2 7/8	6 1/4	1 3/4	1 1/16	7/16	7/8	1/2
3 11/16	3	6 3/4	1 3/4	1 3/16	7/16	7/8	1/2
3 15/16	3 1/8	7 1/4	1 3/4	1 5/16	7/16	7/8	1/2
4 3/16	3 1/4	7 3/4	2	1 7/16	1/2	1	9/16
4 7/16	3 3/8	8 1/4	2	1 1/2	1/2	1	9/16
4 15/16	3 5/8	8 3/4	2 1/4	1 1/2	9/16	1 1/8	9/16
5 7/16	3 7/8	9 1/4	2 1/4	1 1/2	9/16	1 1/8	9/16
5 15/16	4 1/8	9 3/4	2 1/4	1 1/2	9/16	1 1/8	5/8
6 7/16	4 3/8	10 1/4	2 1/4	1 1/2	9/16	1 1/8	5/8
6 15/16	4 5/8	10 3/4	2 1/2	1 7/16	5/8	1 1/4	11/16
7 7/16	4 7/8	11 1/4	2 1/2	1 7/16	5/8	1 1/4	11/16
7 15/16	5 1/8	11 3/4	2 1/2	1 7/16	5/8	1 1/4	11/16
8 7/16	5 3/8	12 1/4	2 1/2	1 7/16	5/8	1 1/4	11/16
8 15/16	5 5/8	12 3/4	2 1/2	1 7/16	5/8	1 1/4	11/16
9 7/16	5 7/8	13 1/4	3	1 5/16	3/4	1 1/2	13/16
9 15/16	6 1/8	13 3/4	3	1 5/16	3/4	1 1/2	13/16

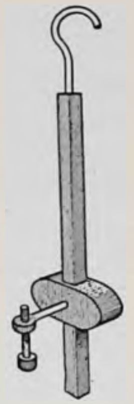


Fig. 11. Leveling Rod for Shafting

The collar usually consists of a ring with a bore equal to the diameter of the shaft plus a small clearance, and fastened upon the shaft with a set screw whose head is countersunk. This form is shown in Fig. 10, and the accompanying table gives the dimensions for various sizes of shafts as computed by Geo. W. Childs.

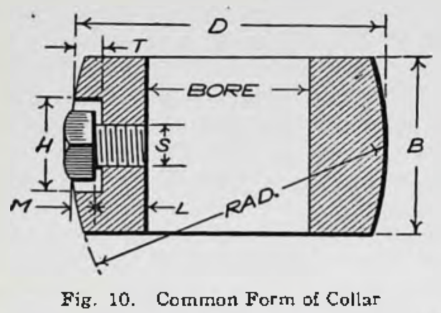


Fig. 10. Common Form of Collar

ALIGNMENT OF SHAFTING

In the mill or machine shop, employing much line shafting, there is perhaps no one place where more power is absorbed and wasted than in poor alignment of shafting.

The difficulty of keeping the alignment correct may be due to changing the location of heavy machinery, uneven settling of floors, uneven wear of the bearings, shafting supports becoming loose, and so forth. To look after the various details and keep the loss of power down to the minimum, requires the closest attention and accuracy in the alignment of the shafting.

The methods adopted for establishing a line for the shafting or correcting the alignment must be worked out to suit the individual case. A method commonly employed, however, is to establish first an accurate line by the use of a stretched wire to which the line of shafting can be compared. This reference line is usually placed directly over the shaft, its level being accurately determined by means of a spirit level, and its position in regard to the machinery and building accurately measured.

Having the reference line accurately placed, and the shafting supported in its bearings, measurements are taken both horizontally and vertically from this line of reference to the shafting, and by means of the screw adjustment in the shafting supports accurate alignment may be secured. This alignment may be checked by means of a carpenter's level or leveling rods, such as shown in Fig. 11, and the alignment in the horizontal plane can be checked by hanging plumb bobs from various points along the line of shafting.

In recent years the surveyor's transit or level has come into prominent use for aligning shafting in mills or machine shops. By the use of this instrument and leveling rod the work of aligning a shaft in the beginning, or of checking its alignment is much more rapid, and the results obtained more satisfactory than by the use of the spirit level method.

In taking the level of a shaft with a level a straight-edge should be provided, which will extend from one bearing to the next and the level is applied to the straight-edge. A carpenter's level is

DATE ----------				
BEARING NO.	IN. HIGH	IN. LOW	IN. TO EAST	IN. TO WEST
1				
2				
3				
4				
5				
6				
7				
8				
INSTRUMENT USED ----------------				
---------------- OPERATOR				

Fig. 12 Record Chart for Shaft Alignment

employed for this purpose, and if applied nearer one bearing, since the shafting must sag some between supports, the level will not indicate the same that it would half way between the two supports and thus lead to error. In testing the alignment of a shaft it is always best to keep a record, such as shown in the illustration, testing the alignment the entire length before any adjustment whatever is made in the position of the bearings, then when the test has been completed the record can be examined, which will show at a glance just which bearings must be adjusted, and how much they must be moved.

SHAFTING SUPPORTS

The various appliances used for supporting shafting may be classed as overhead hangers, post hangers, or pillow blocks. The essential feature of these supports is to maintain a bearing which is perfectly rigid, presents a low frictional resistance and can be adjusted readily.

The general shape of the bearing support is triangular with the bearing in one corner. This gives a rigid frame where it can be attached to beams, posts, piers, etc. Overhead hangers are fastened to beams in the ceiling and usually with bolts or lag screws, though the latter should be used only for light work. In modern reinforced concrete construction, special means are found necessary, as boring holes in the concrete is a difficult matter after it has become set. In Fig. 13 are shown several different arrangements for supporting hangers in reinforced concrete work.

Overhead hangers should be provided with some means for removing the shafting without taking down the entire hanger. This is accomplished in some makes by a hook-shaped frame-work, while in others the frame-work is in pieces, thus allowing the part attached directly to the bearings to be removed. In countershaft hangers, this provision is not necessary, as the shafts are usually short and can be removed by slipping them endwise through the bearing.

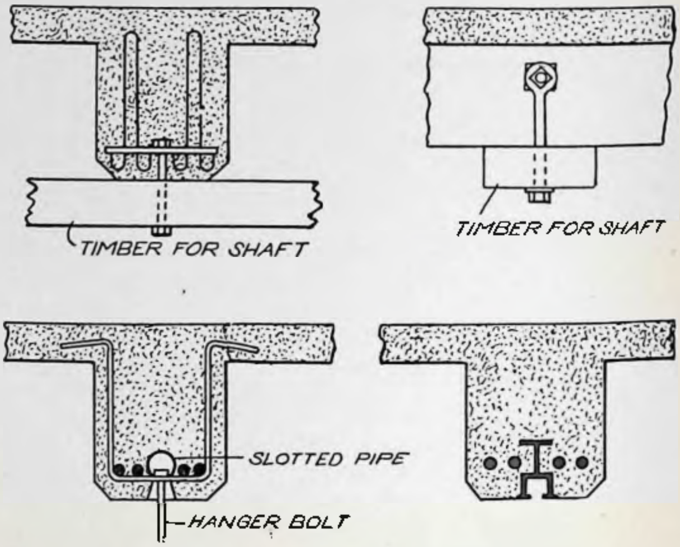


Fig. 13. Methods of Supporting Shaft Hangers on Reinforced Concrete

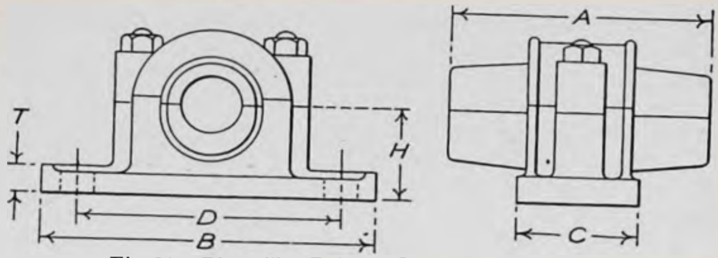


Fig. 14. Ring-oiling Ball and Socket Pillow Block

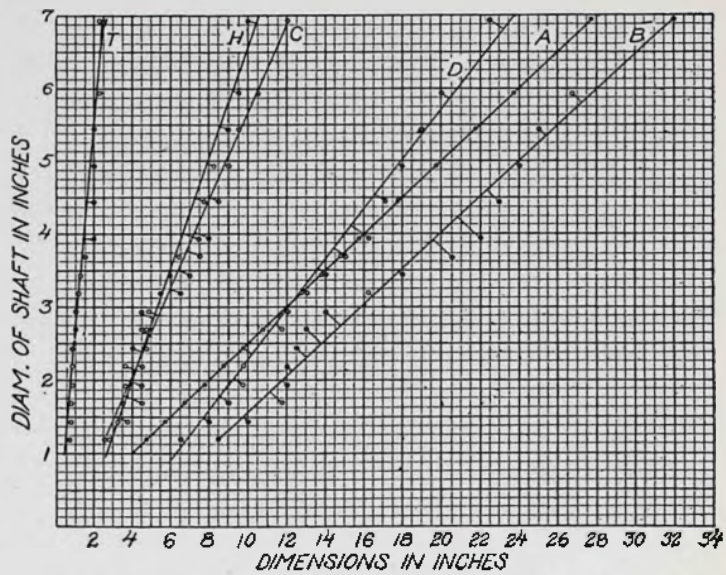


Fig. 15. Proportions of Ring-oiling Ball and Socket Pillow Block

Overhead hangers are made adjustable in the vertical direction by means of screws, wedges, or the use of liners. Horizontal adjustment is made by providing oblong holes through the frame of the hanger for the supporting bolts, thus allowing the hanger to be shifted at right angles to the shaft. Some forms of hangers are fitted with ball and socket bearings, which allow the bearing to rotate slightly in the horizontal plane to accommodate itself to the shaft alignment.

Wall or post hangers are fastened to the side of a wall in a similar manner to that employed for supporting the overhead hangers. These also have either rigid or ball and socket bearings, and adjustment is made in a vertical direction by providing oblong holes for the supporting bolts or by means of screws, in the horizontal direction liners or screw adjustment may be employed. In this style of hanger it is quite frequent to make the bearing part of the supporting frame, lining it with some sort of bearing metal. In this case there is no need of supplying means for removing the shaft, as it can be lifted out of the bearing by simply removing the upper half.

Pillow blocks are placed on pedestals of iron, masonry or wood, and consist of the bearing with suitable means for holding it rigid and for adjusting the alignment of the shaft in both vertical and horizontal directions. Adjustment is made either by screws, wedges, liners or oblong holes for the retaining lag screws as in the other forms of shaft supports.

Proportions of various shafting supports vary widely with the styles, and ideas of manufacturers. The shaft diameter is the basis, however, for calculating the bore and the other dimensions of the hanger. To illustrate this refer to Fig. 14, which shows a ring-oiling ball and socket pillow block made by W. A. Jones Foundry & Machine Co. The dimensional values have been used in plotting the curves in the Fig. 15, and in each case the dimension bears a certain relation to the diameter of the shafting, which is deviated from but little, in order to overcome certain difficulties in the manufacture of the article, also to keep within standard dimensions established by the maker. This relationship is particularly noticeable in regard to the length of the bearing, there being an exact ratio of 4 to 1 throughout the entire range of shaft diameters.

In like manner, a rigid post hanger, Fig. 16, is used as a typical example, and dimensions for various sizes of hangers have been plotted against the shaft diameters and here also definite relations exist. The ratio of the length of bearing to the diameter of the shaft is 3 to 1; this is not so great as in the case of the ball and socket pillow block, owing to the fact that the post hanger has a solid bearing which is made shorter in order to overcome difficulties in the alignment of the shafting.

It is becoming more common to supply shaft hangers with separate bearings which are provided with ball and socket joints, making them flexible to a certain extension, yet maintaining the alignment necessary for best operation. The bearings are lined with Babbitt-metal, and provided with means for continuously supplying lubrication in sufficient quantities.

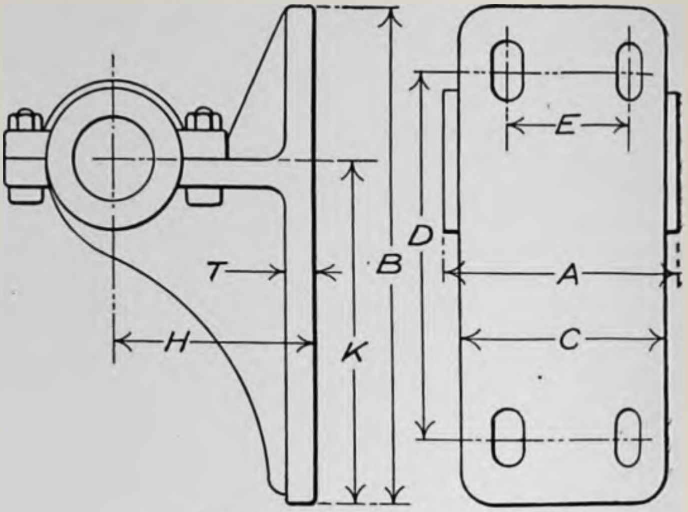


Fig. 16. Solid Post Hanger

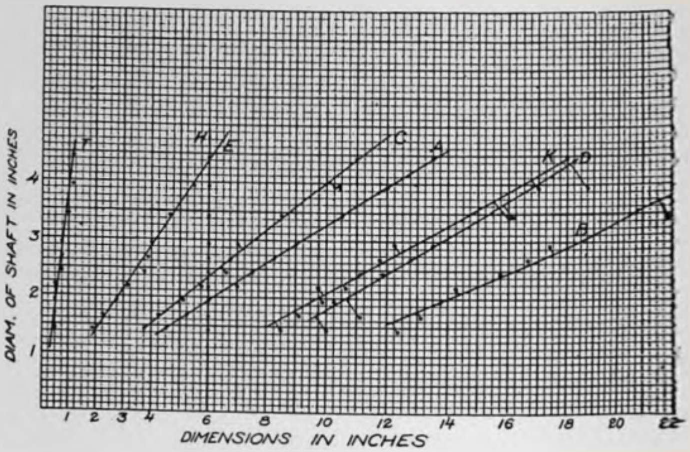


Fig. 17. Proportions of Rigid Post Hanger

The pressure employed on bearings varies widely with the bearing metal employed, the speed of operation and the manner of lubricating. It is customary to supply bearings which have lengths from two to four times the diameter of the shafting which has been found to give satisfactory operation. With ball and roller bearings it is necessary to employ a hard bearing surface on the shaft and in the interior of the bearing.

Spacing of shaft hangers is governed principally by the deflection of the shaft which should never exceed 0.01 in. to 1 ft. of length. For ordinary line-shaft work it is the usual practice to space the hangers 8 ft. on centers. This, however, varies somewhat in special cases and Tables 1 and 2 give the distance between bearings for different size shafting and special arrangement of pulleys. A heavy driving pulley should be supported on both sides by hangers, and it is well in all cases to have the shaft well supported with hangers properly adjusted to give accurate alignment of the shafting.—*Practical Engineer.*

Luck and Labor

Luck is ever waiting for something to turn up. Labor with keen eyes and strong will, will turn up something. Luck lies in a bed and wishes the postman would bring him the news of a legacy. Labor turns out at six o'clock and, with busy hand and brain lays the foundation for a competence. Luck whines; labor whistles. Luck relies on chance; labor on character and energy.

The gates for the Panama canal weigh 92 tons each. No chance for the boys to lift them Halloween night.—*Los Angeles Times.*

WHAT CONSTITUTES SUPERIORITY IN AN AIRSHIP*—Part II

COMMANDANT PAUL RENARD

III

These general considerations are not mere digression from the question which we are considering today. We must not lose sight of them if we wish to estimate things clearly. Do we not often hear the remark: "Of what importance are dirigibles or aeroplanes? They do not travel as fast as railroad trains; they have much less carrying capacity than boats; would it not be worth while rather to perfect the time-honored land or maritime means of travel than to search for a new method of transportation?"

If aerial navigation did not differ in its essential properties from these other modes of locomotion known from the most ancient times this presentation of the case would be entirely rational, but when men pursue so indefatigably the conquest of the air and the public follows its progress with such interest, it is not because they hope to discover in this way the means of possessing in a higher degree the qualities of speed and capacity desirable in any vehicle; it is because of qualities found alone in aerial navigation. If this were not so the conquest of the air would still certainly be an important question, but it would not be worth all the efforts that it brings forth and the excited interest that it arouses.

We cannot actually realize what is before us, but there is today an idea latent in every mind that the investigation into aerial locomotion is not a vain caprice of mankind, but springs from a deep and instinctive feeling that extraordinary changes are impending in the conditions of humanity.

We must now go a step further into the detailed study of the qualities which we have enumerated and choose the most important.

The first quality which I mentioned is the faculty of ascending to the greatest possible height. The means for accomplishing this end are different, according to whether machines are heavier or lighter than air. In the first case, it is necessary to have at your disposal a motive power greater than that necessary to sustain and move the machine in a horizontal plane. It is, therefore, a question of the power of the motor.

If, however, the air-ship is a dirigible balloon, the motor does not come into consideration. It is only necessary to throw off a definite weight of ballast, and the greater this quantity is for a given balloon the higher it will ascend. Besides the weight of the motor and the mechanism itself and the weight of the fuel and other supplies and of the passengers, arrangements must also be made for a supplementary weight that can be sacrificed. It is not enough to increase the volume of the gas envelope in order to increase the dispensable ballast in the same proportion, for the altitude attained does not depend on the absolute amount of ballast thrown off, but on the ratio of this weight to the volume of the balloon. If, for example, with a balloon of 1,000 cm. an altitude of about 2,300 meters should be attained by releasing 250 kg. of ballast, to attain the same altitude with a balloon of 2,000 cm. capacity, not 250 kg., but 500, must be thrown off. If the weight of the air-ship itself, the motor mechanism, the supplies, and the passengers increased proportionately with the volume of the gas envelope, we would always have the same proportion of ballast and could ascend no higher in one case than in the other. This, however, is not the fact, for large balloons can carry a larger proportion of ballast than small ones, and it is with these that high altitudes are most easily attained. The altitude is, therefore, to a great degree a question of volume.

It may be remarked that if lighter motors for a given power are provided, or greater power for a given weight—in other words, if the weight is reduced, there would be more dispensable weight, more ballast per horse-power, and, consequently, a greater capability of ascension. It is also evident that to attain an extreme elevation the weight carried should be reduced as much as possible. Thus the number of passengers should

*Reprinted from Annual Report of the Smithsonian Institution.

be reduced to a minimum and little or no extra material carried. By doing this, in the case of a dirigible, the dispensable ballast can be increased to the extent of the economy which has been realized in the rest of the equipment. In the case of an aviation machine if its total weight is diminished, and, consequently, the expenditure of motive power necessary to sustain the machine, the excess power available for attaining altitudes is thereby also increased. To sum up, in all air-ships, of whatever kind, altitude may be attained with a facility corresponding to the power available for a given weight, but with dirigibles the principal method of reaching higher altitudes is by increasing the dimension of the gas envelope.

An aerial voyage can be prolonged as long as supplies remain available, whether the air-ship be lighter or heavier than air. The most important of these supplies is fuel for the motor and the accessory lubricating oils, the weight of which is comparatively small. In dirigibles there must also be a supply of ballast proportionate to the length of the voyage. The quality of duration is, therefore, a question of transporting capacity, and the methods of obtaining it are the same.

The distance that can be covered is evidently proportional to the duration of the trip, and is also proportional to the absolute velocity of the air-ship. We have just considered the duration; as for the absolute speed, it is a quality that must be considered by itself. We have, therefore, as regards distance, only one thing to keep in mind, and that is, it is obtained by combining the means used to attain duration and velocity.

As already stated, absolute velocity is a resultant of two velocities, that of the wind and that of the air-ship; with the wind we can do nothing, but the individual velocity is another matter. It may be remarked that if the individual velocity should be less than that of the wind, the machine would not advance but would recede more or less from its point of departure. Such a machine, however, would not be dirigible and would not deserve the name of "air-ship." We mean to consider here only devices really dirigible, that is, those whose velocity is greater than that of the prevailing wind. In this case, whether flying against the air or with it, the absolute velocity will increase with the individual velocity. Let us suppose that the wind blows 50 km. an hour. The air-ship with an individual velocity of 60 km. will make 10 km. an hour against the current and 110 with it. If it has an individual velocity of 70 km., it can travel 20 km. an hour against the wind and 120 with it. In either case it is evident that the absolute velocity increases with the individual velocity. One can even demonstrate mathematically that when an air-ship describes a closed circuit corresponding approximately to the form of a circle or a regular polygon, whatever may be the velocity and direction of the wind the one that possesses the greatest individual velocity will have the greatest average absolute speed around the whole course.

As we cannot affect the velocity of the wind, to seek to increase the absolute velocity is in fact to seek the greatest individual velocity. We have just seen how desirable this quality of speed is in itself. Without it dirigibility is impossible; and the greater it is the more frequent are the occasions when we can travel in all directions and the greater will be the distances covered. Speed is, therefore, in respect to importance, the principal quality in an air-ship, without which it is but the plaything of the winds, and it is toward the improvement of this feature that all efforts should be directed.

How may this individual velocity be obtained? In dirigibles all resistance to forward movement must be diminished as far as possible; this is accomplished by appropriate design of form. This form must be permanently maintained, powerful motors must be provided, driving good propellers. To sum up, every improvement which can be devised with regard to dirigible balloons should be directed principally if not solely toward the increase of their individual velocities.

The same is true with regard to aviation apparatus; but in this direction the difficulty is much less, for because of their light design they offer much less resistance to forward motion than the dirigibles, condemned to drag along their enormous bags filled with hydrogen. For a given motive power, therefore, the former can attain much greater speed than balloons, as experience has superabundantly demonstrated.

However that may be, for the one or the other the individual velocity is a question of motive power, and since in an air-ship only a limited weight can be allowed for the motor, this must have as great a specific power as possible; in other words, the weight of the gas engine should be reduced as much as practicable. The question of individual velocity thus depends on the lightness of the motors. This motive power must, furthermore, be utilized to the best possible advantage, which can be done by proper propellers. The resistance to forward movement must be diminished, and this can be accomplished by careful design. The air-ship must also be stable in all directions—horizontally, longitudinally, or transversely—for yawing, pitching, and rolling, apart from the wearying effect on passengers and the dangers they may present, are formidable obstacles to the best speed. When a dirigible moves sidewise it presents an enormous surface to the air of a shape deplorable from the point of view of resistance, and the speed is diminished to an inconceivable degree.

One can almost sum up in a word what can be said about individual velocity. It is this, that for an air-ship to possess this quality in the highest degree, it must be endowed with all the others.

There remains now the carrying capacity. Here the question appears in quite a different light, according to whether the apparatus is lighter or heavier than air.

With a dirigible it is simply a question of the volume of the balloon. It must not be thought, however, that by increasing indefinitely the volume of the gas envelope that the carrying power of an air-ship can be increased without limit. To enlarge the volume means to increase the fabric surface and this will demand greater strength in a large balloon than in a small one, which will increase the weight of a square meter of the envelope and accordingly result in a double cause of increase in the total weight. This will also be true with regard to the suspension cords and all the material constituting the dead weight.

It can be demonstrated that in balloons of different volumes this dead weight increases nearly as the fourth power of the linear dimension; that is, more rapidly than the volume. Thus, in a balloon of twice the volume, the dead weight will not be multiplied by 2 but 2.52, and with triple the volume the dead weight will be multiplied not by 3 but by 4.33, and so on. In spite of this unfavorable circumstance, however, we may say in the limits of practice, that the carrying capacity increases with the volume. It increases also with the lightening of the motors, for if the motor is lighter for a given power the economy in weight so realized can be used to increase the weight carried; in general, however, it is preferred to profit by this lightening by increasing the motive power and consequently the speed.

In a dirigible the total ascensional force is the product of the volume of the balloon by the lifting power of a cubic meter of gas. This latter quantity depends entirely on the specific gravity of the air and of the gas employed. As long as no gas lighter than hydrogen can be found there can be no hope of a change in the present conditions, and even if such a gas should be discovered, we should always be limited by the weight of a cubic meter of air, 1.293 kg. This figure represents the extreme limit of weight that a cubic meter of the gas could lift, if it weighed nothing. However, a cubic meter of pure hydrogen weighs only 0.090 kg.; a cubic meter of this gas therefore raises a weight of 1.203 kg., and even if there existed a gas of zero density, only 90 grams per cubic meter would be gained over the lifting power of hydrogen.

Consequently, it is true at the present day and always will be, that the total lifting power of a balloon can be increased only by an enlargement of its volume.

In an apparatus heavier than air this total ascensional force is again equal to the product of two factors; in this case, however, it is the surface of the sustaining planes and the supporting power per square meter. To increase this total ascensional force it thus becomes necessary to increase one or the other of these factors.

Theoretically, the dimensions of the sustaining planes can be increased, but in practice it is difficult, for these surfaces become much heavier as they increase in size, and thus absorb a large part of the increase of ascensional power attained thereby. If this is carried still further, the weight of the sustaining surfaces can be increased to such an extent that all the benefit of the increase in size is lost, and even more. We should, therefore, endeavor to increase the carrying power per square meter of the sustaining planes.

This carrying power may be increased partly by an increase in the sustaining quality of the bearing surface, and it is research in this direction that practically leads to the perfection of devices heavier than air. It is a question of form, dimensions, and orientation which must be taken up in detail. This problem constitutes in reality nine-tenths of the problem of aviation.

In another way the load that can be carried per square meter of sustaining surface in a given apparatus, increases with the available motive power. The greater this power is in comparison with the weight of the machine the larger may be the load imposed on each square meter of sustaining surface. The increase is not proportional, but it is rather rapid, as may be shown by a few figures. If an aeroplane provided with a 25 h.p. motor can carry 10 kg. per square meter, the same aeroplane with a motor of 50 h.p. can carry 16 kg.; with a 75 h.p. motor, 21; and with a 100 h.p. motor 25 kg. per square meter.

There is one very interesting point to note here, and that is, for a given aeroplane the capacity per square meter varies with the velocity. Let us suppose that our aeroplane, with a 25 h.p. motor and carrying 10 kg. per square meter, makes a speed of 60 km. per hour. When it is provided with a motor of 50 h.p., which will permit it, as we have just seen, to carry 16 kg. per square meter instead of 10, its velocity will be increased. It will no longer be 60, but 76 km. per hour. In the same way, if it has a 75 h.p. motor due to which its carrying capacity increases to 21 kg., its velocity will at the same time reach 86 km. Finally, with the motor of 100 h.p., and a load of 25 kg. per square meter it will have a velocity of 95 km.

The individual velocity and the carrying capacity therefore increase with the power of the motor; nothing of the kind occurs with dirigibles.

However that may be, whether dirigibles or aviation apparatus are concerned, the carrying capacity is dependent on the lightness of the motors and the general perfection of the whole device; but these features have a much greater effect in the heavier-than-air system than in the lighter-than-air. In dirigibles there intervenes in this question a preponderating element, that of the volume of the gas bag whose influence dwarfs all others. This element does not exist in the aviation devices.

We have still to examine stability in all its forms, but, as we have already seen, this property is indispensable if we desire to attain an individual velocity of any magnitude whatever. There is, therefore, no necessity to analyze it in detail. We will simply remember that a rapid air-ship is necessarily stable.

IV

From the foregoing, the conclusion may be drawn that the different qualities which an air-ship may possess are not independent of each other, but may be reduced to two fundamental properties: the individual velocity and the carrying capacity. The first of these qualities, the individual velocity, is highly desirable in itself, for without it dirigibility is impossible. Furthermore, it is the only means by which we can increase the absolute velocity, which is of such practical importance. Finally, the absolute velocity is one of the factors determining the distance that can be covered in a single flight. When the individual velocity is increased, for the same reason both the absolute velocity and the distance covered are increased. If we also add the consideration that the possession of this speed necessarily implies the possession of stability in all directions, we must conclude that in it we have a quality that is essentially fundamental.

The carrying capacity of such a machine can be measured by the amount of weight of every kind which it can carry in excess of the weight of the air-ship proper, its motor, propellers, and all the parts indispensable to its operation.

Given this weight it can be used in different ways. It can be employed in transporting a number of passengers or a considerable weight of merchandise. In the form of ballast it helps to attain the greatest altitude, and thus contributes to the duration of the aerial voyage. In the form of fuel supply it assures the duration of the voyage, thus affecting one of the two factors entering into distance covered.

Individual velocity can not be present in a high degree if the property of stability is not also present. This permits of the attainment of an absolute velocity which, coupled with duration of voyage, goes to make up distance traveled. The carrying capacity has no relation to stability. It can be utilized either for its own sake, or to attain altitude, or to prolong the voyage and thus contribute in increasing the distance traveled.

These different qualities may, therefore, be divided into two groups, those dependent on the individual velocity, and those on the carrying capacity. As for the distance traveled, it is a common resultant of the two groups, for it is the product of absolute velocity by duration of flight, qualities belonging to the different groups.

If we wish to obtain a synthetic idea of the value of an air-ship, it is by the ratio of the distances covered that their merit should be measured, but this quality is only the product of two others —the absolute velocity and the duration of the voyage. These two factors may play a varying role in the final result.

The factor of duration is certainly less important than the velocity. To obtain duration the machine need not even be dirigible; a simple free balloon can possess this quality, while up to the present time it is the spherical balloons which have made the longest uninterrupted voyages, so that while recognizing the valuable index which the distance traveled affords in the estimation of the merit of an air-ship, still, of the two elements which go to make it up, we must attach more importance to the absolute velocity than to the duration of flight.

It should be recalled, however, that these two qualities are not fundamental. The absolute velocity itself depends on the wind and the individual velocity, and from our point of view it is only important if it is attained by the caprice of the wind but in the direction desired by the pilot. To accomplish this, there must be individual velocity, a fundamental property.

The duration of flight is itself dependent on the carrying capacity. We must, therefore, conclude that of these two fundamental properties it is the individual velocity that stands first and the capacity of transport takes second place.

As stated in the beginning of this discussion, I have arrived at these conclusions simply from utilitarian considerations. If we examine the question from the point of view of the difficulties to be overcome, what rank shall we assign to these two essential qualities of an air-ship? For an aeroplane the question is very simple; the difficulties are the same in acquiring one as in acquiring the other. With an increase in the individual velocity, the possible load per square meter of sustaining surface is increased. Consequently, in making an advance in one a gain is made in the other. The question can be summed up by saying that an aeroplane should be as perfect as possible; that is, it should be stable, have carrying surfaces endowed with the best sustaining qualities, a good propeller, and a powerful and light motor. If it possesses such perfection it can be used in any way desired; it can travel swiftly and yet carry a considerable weight that may be utilized either as useful load or to increase the duration of the flight. If its load is lightened its speed will be diminished, but its abundant motive power will enable it to ascend. To conclude, with a perfect aeroplane the aviator may obtain whichever quality he desires or combine them in whatever proportion he deems convenient.

In the case of aeroplanes, therefore, we may say that the question of difficulties to be overcome is negligible, and that utilitarian considerations alone determine their value. In these machines it is the individual velocity, as it is in all other types, which is the most important quality, but the others can be obtained without modifying the construction in the slightest degree, and except for attaining altitude, without losing any velocity, but even gaining it, with an increase in the carrying capacity and in the qualities which are dependent on it.

This is not the case with dirigibles. To be sure, with them as with aeroplanes, general perfection of apparatus—motor, propellers, forms of small resistance—is indispensable to velocity and can likewise exert a favorable influence on the carrying capacity and its resulting consequences, but another factor intervenes, the volume of the balloon. This exerts an enormous influence on the carrying capacity, which dwarfs that resulting from the general perfection of the apparatus. Although by increasing the individual velocity we can indirectly increase in a slight degree the carrying capacity, we possess, moreover, a means of increasing this quality absolutely independent of those which produce velocity. I may add that this method has no great merit in its application. It is not very difficult to add a few hundred cubic meters to a balloon, or even more. I would not go as far as to say that the problem is of extreme simplicity, but it is a small matter beside those that have to be solved in increasing the individual velocity of a dirigible. Consequently, as far as machines lighter than air are concerned, if from a utilitarian point of view the carrying capacity is an inferior quality, it is equally so from a technical standpoint, for it is much easier to attain than individual velocity.

Thus there are in an air-ship only two fundamental qualities from which all the others are derived, individual velocity and carrying capacity; and from a practical standpoint the latter is much less important than the former.

In considering the difficulties to be overcome, in an aeroplane the question does not rise, for in such apparatus the qualities sought for are so involved one with the other that every added improvement allows of the increase according to choice of one or the other of the properties desired in an air-ship. With dirigibles this is not the case, for carrying capacity is much more easily obtained than individual velocity, and the technical considerations which are involved in machines lighter than air are merely those that are basic in the utilization of an air-ship.

Simply because a colossal dirigible has accomplished long journeys and covered great distances, the superiority of this type of air-ship over all others should not necessarily be proclaimed. The machine that should interest us most is the one capable of the greatest individual velocity, and as this velocity is difficult to measure, we should estimate it from the absolute velocity attained in flying in a closed circuit in such a way as to eliminate from the final result, as much as possible, the effect of the wind.

Photographic Telegraphy

A new system of rapid telegraphy, or photographic telegraphy, as it is called, invented by Pollak Virag, has been officially recognized by the postal authorities, and permission has been given to the press to use it in France. The first practical trial of the system, which, it is said, delivers a clean copy of forty thousand words an hour, was made when the *Eclaireur de Nice* had its Paris dispatches transmitted by the system.

The principle of the invention, which seems likely to bring about a revolution in prevailing methods of telegraphy, is an ingenious application of photography to telegraphy. Electric current, transmitted on telephonic wires, operates at the receiving station on a small mirror, upon which is thrown a powerfully concentrated ray of light. The mirror is automatically made to move upward and sideways, following the shape of letters in handwriting. Opposite the mirror is placed a roll of photographic paper, upon which is focused the reflection of light on the mirror. Specially prepared paper presents a faithful copy of the message transmitted.

There is more economy in keeping your eye on the meters than on the clock.

THE HOME CRAFTSMAN

RALPH F. WINDOES

USEFUL ARTICLES IN WOOD AND METAL

The next few designs will give us a combination, not only pleasing in effect and easy in construction, but it also opens a field of suggestions for many beautiful and useful articles. These are all of quarter-sawed oak, upon which brass or copper pieces are mounted. The metal may be decorated in a number of ways, two of which are here presented: the etched design and the sawed piece.

The wood should be filled, stained and waxed to the satisfaction of the craftsman, and all metal work should be lacquered after it is finished.

The designs here presented are suggestions, and the craftsman should originate his own, at least for the decorative panels. The working drawings do not show in the slightest the rare beauty of the articles, and they must be made to be appreciated. The cost for each article is so slight and the work so interesting that every craftsman should make every article for himself or his friends.

Calendar

The calendar shows an oblong board, with the corners rounded, upon which is mounted a calendar pad and a brass panel for decoration. The panel has an etched design, that is, the darker portion of the design has been eaten away by acids, leaving the design standing out away from the background. How this is done will be explained later on. The material needed for the calendar, exclusive of the stain, filler and wax, is as follows:

1 piece quarter-sawed oak, ½ x 3 x 9 in.
1 piece No. 18 gauge soft brass 2 x 4 in.
4 ½ in. brass escutcheon pins.
1 calendar pad.
1 small brass screw-eye.

First, the edges of the board should be smoothed up and the corners rounded. Then the finish should be placed upon the wood, so that it may have time to dry before the brass is mounted. Next, the design should be etched upon the brass, as follows:

ETCHING OF METAL

Thoroughly clean the surface of the copper or brass with steel wool or pumice stone. Transfer the design from the paper upon which it is drawn to the metal by means of carbon paper, being careful not to rub the lines off after they are once in place. Procure a little asphaltum varnish at a paint store and go over all of the design with it that is *not to be etched*, including the back and the edges. This is accomplished by painting it on with a rather fine brush. Be sure that the asphaltum is covering every part that is not to be etched, and that it is thick enough to prevent the acid from eating through it. The back and the large portions of the design may be painted on with a larger brush. If the varnish does not work easily it may be thinned with turpentine.

Allow this to dry thoroughly, and then immerse it into a solution of one part nitric acid to two parts water. In making this solution be sure to *pour the acid into the water*. It should be kept in an earthenware dish while in use, and afterward it may be transferred to a bottle, as it may be used a number of times, with the addition of a little acid each time.

When the acid reaches the exposed metal, little bubbles should arise, which show that the etching process has commenced. It should continue from one to five hours, depending on the strength of the solution used and the composition of the metal. The craftsman should take it from the acid occasionally, to see how the etching is progressing. When he thinks it is etched deep enough, experience will tell him, he should take it from the acid and wash it in clear water. Next, it should be soaked in a dish of turpentine, which loosens up the asphaltum and allows it to be taken off the piece with a rag. Finally, it should be washed with soap and water and allowed to dry.

There does not appear much contrast now between the etched and the unetched portions, so the former should be darkened a little to bring out this effect. Two colors will now be spoken of, a green and a dark brown, nearly black. These colors are put upon the piece after which the high lights are lightened by rubbing with pumice or steel wool.

The green effect may be obtained with the following verdigris solution:

Copper nitrate, 48 gr.
Ammonium chloride, 48 gr.
Calcium chloride, 48 gr.
Water, 3 oz.

This formula will be compounded for the craftsman by any druggist, and it should be painted upon the metal. Perhaps more than one coat will be necessary to bring out the depth of color desired.

The dark brown effect results from a strong solution of butter of antimony, into which the piece is placed. This darkens the metal, after which the high lights should be rubbed up as before mentioned.

All metal work when completed should receive a coat or two of lacquer, or banana oil.

To return to the calendar: after the brass panel is finished it should be mounted on the wood with the escutcheon pins. The calendar pad should be glued into place and the screw-eye inserted to hold the piece onto the wall.

Necktie Holder

The material needed for this piece is:

1 pc. quarter-sawed oak, ½ x 3 x 9 in.
1 pc. No. 18 gauge soft brass, 2 x 3¼ in.
1 pc. No. 18 gauge soft brass, 1 x 9 in.
8 ½ in. brass escutcheon pins.
1 small brass screw-eye.

The wood should be worked up exactly as in the case of the calendar. The design here shown is conventional, and is etched and finished as before stated. The brass strip is formed and mounted as shown in the side elevation of the drawing, and is mounted with the escutcheon pins. It should be polished and lacquered before being mounted.

Book Ends

Next, we have a design for a book end which works up easily and presents a very beautiful appearance when finished. Of course a pair of them will be needed, which will require the following material:

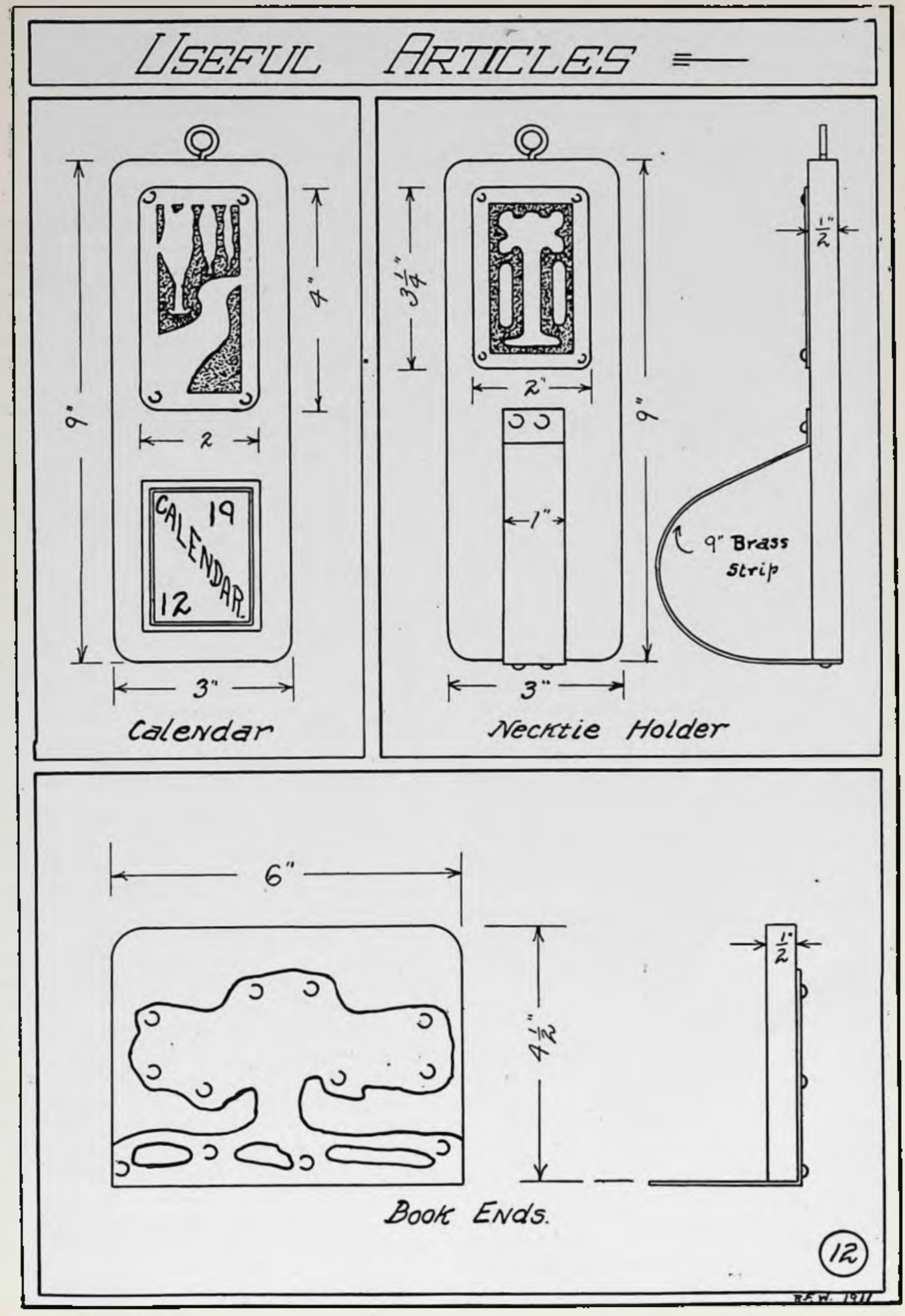
2 pcs. quarter-sawed oak, ½ x 6 x 4½ in.
2 pcs. No. 18 gauge soft brass, 6 x 6½ in.
24 escutcheon pins or large-headed brass tacks.

The grain of the wood should run vertically, that is, up and down, and should be finished to suit the builder. Notice that but two of the corners are here rounded.

The design should next be drawn out full size and transferred to the metal. Leave about 2½ in. to be bent under the wood to support the end. Next, form, from a piece of waste material, a stick having a V-shaped groove in one end. This V should run back into the wood for about 3 in. The stick is fastened securely onto the bench and the metal held tightly against it so that the part to be sawed away is directly over this groove. If the metal is allowed to move while sawing, the saw is very likely to be broken. Saw around the outside of the design, using the jeweller's saw frame, with an easy, vertical movement. Do not hurry the sawing. When the outline has been cut out, drill holes through the parts to be removed from within the piece, insert the saw blade through these holes, fasten it in the frame and continue the sawing. When the sawing is completed, file the edges of the metal with a very fine file and rub them with emery cloth until they are very smooth. Polish the piece, lacquer it; bend it in shape and fasten it to the wood. The escutcheon pins hardly show enough head for this work, so it would be well to use large-headed brass tacks, such as are used to fasten wooden bottoms in chairs.

Pipe Rack and Match Boxes

Another small article which the man-of-the-house generally finds useful is the pipe rack and match boxes. The


USEFUL ARTICLES
9"
4"
2
3"
CALENDAR
19
12
Calendar
3¼"
2"
1"
9"
½"
9" Brass Strip
3"
Necktie Holder
6"
4½"
½"
Book Ends.
12

material needed for the one we have here designed consists in:
1 pc. quarter-sawed oak, ½ x 6 x 12 in.
1 pc. quarter-sawed oak, ¾ x 2½ x 11 in
1 pc. No. 18 gauge soft brass 3¼ x 5½ in.
2 pcs. No. 18 gauge soft brass 2½ x 3¾ in.
20 ½ in. brass escutcheon pins.
Few 1½ in. brads.

First, work the woodwork to size and dimensions. The holes for the pipes should be laid out with the wing dividers, so that they may be accurately spaced. Care should be taken in boring them so as not to split the edges, and the boring should be done from both sides of the piece. The two are fastened together with brads and the finish applied.

The drawing shows the pattern of the match box, and little trouble should be experienced in laying it out. It is bent on the dotted lines and this should be done over the sharp edge of a piece of hardwood to insure sharp corners on the bends. The boxes are nailed in place with the pins. The decorative effect here shown is produced by the sawing out of a frame from the brass and mounting it over a small motto card. An attractive picture could be used in its stead, or if the craftsman would care for something useful, he could insert a piece of sand-paper and use it as a match scraper. Another beautiful effect is obtained by painting the motto on the brass and etching away the background. If the craftsman thinks himself capable of doing this neatly, it is advised that he do so above all the other suggestions.

The two small holes above the boxes are to serve as hangers, unless the maker desires the screw-eyes, as before illustrated.

Whisk Broom Holder

The whisk broom holder is one of the most beautiful articles shown besides being one of the most useful. It needs:
1 pc. quarter-sawed oak, ½ x 6 x 8 in.
1 pc. No. 18 gauge soft brass, 4 x 4½ in.
1 pc. No. 18 gauge soft brass, 2 x 6¾ in.
13 ½ in. brass escutcheon pins.

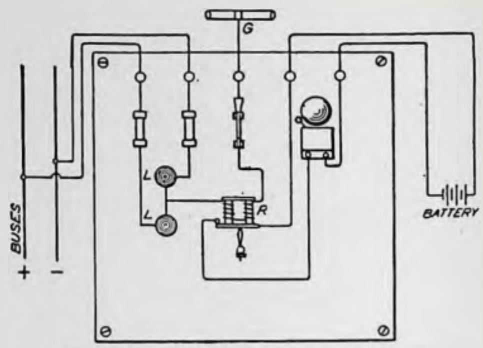
The decorative panel is etched and with a green background. When this is complete it should be turned over on a piece of soft wood and the center of each square should be pounded out a little with the pein of the hammer. This makes a very pleasing effect. The pattern for the holder should be easily understood, and little trouble should be experienced in the finishing of the piece.

(To be continued)

Alarm Ground Detector

W. O. DAVIS

This summer I made an electric alarm ground detector, as the engineer of the plant was not always aware of a ground, and the only way he knew was to test with his voltmeter. On his switch board he had a voltmeter switch with eight points, three are used for three generators and two are used as a ground detector. He had the switch set for the line voltage, and only when he thought of it would he test for a ground.

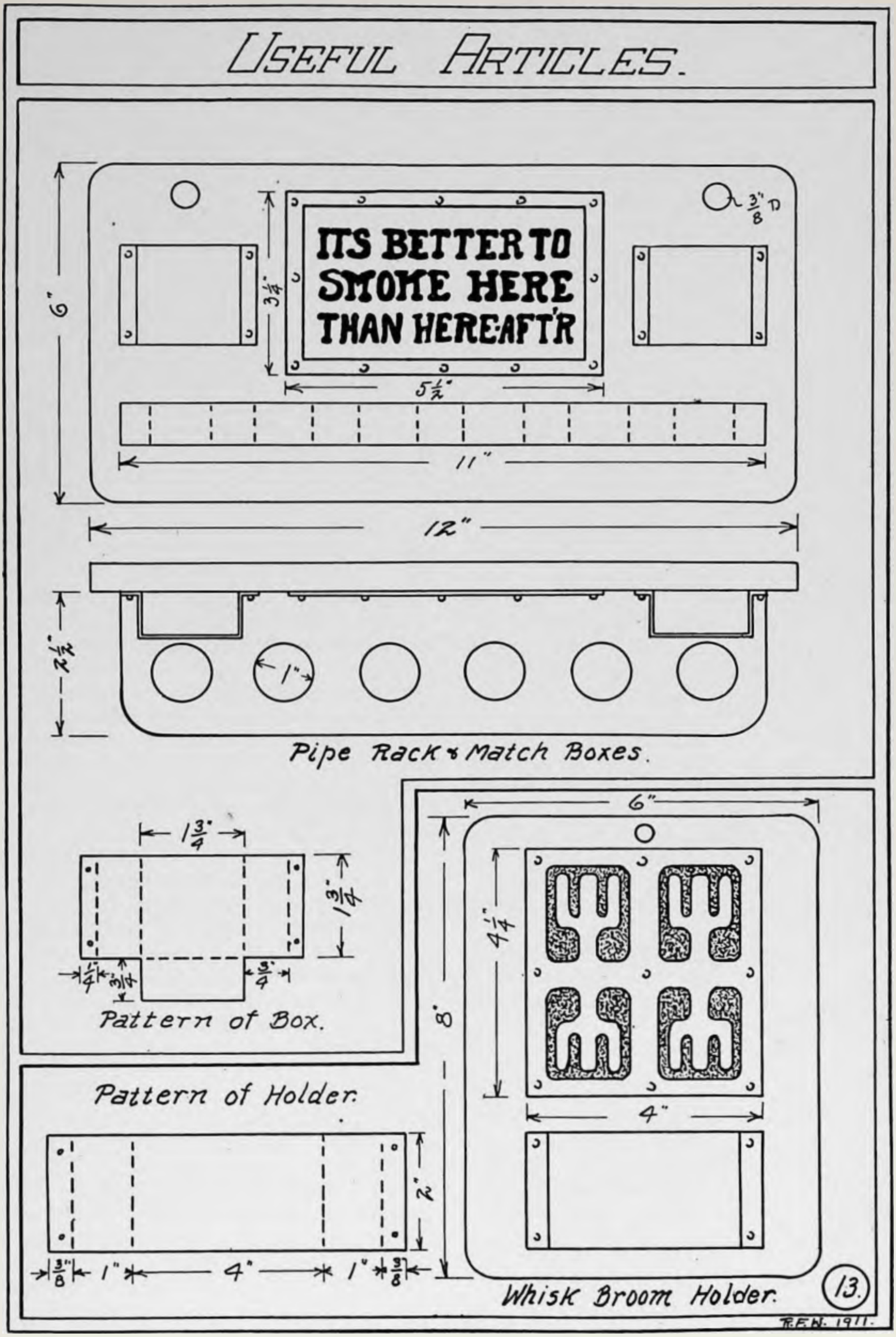


CONNECTION FOR ALARM GROUND DETECTOR

I enclose a diagram of the alarm ground detector as it may be of use to some engineer. The idea is to connect two lamps of the same voltage, 16 c.p., in series across the busbars of the switchboard. Make a connection between the two lamps and connect to one side of the relay about 20 to 30 ohms resistance, the higher the resistance the more sensitive the relay is; on the other side of the relay connect to a switch connected to ground. The armature of the relay is in circuit with the bell. When the ground comes on, by opening the switch the bell stops ringing and the ground can be found.—*Practical Engineer.*

Anger and worry not only dwarf and depress, but sometimes kill.—FLETCHER.

Busy yourself with the important things of life; there is not time for others.


USEFUL ARTICLES.
ITS BETTER TO SMOKE HERE THAN HEREAFT'R
6"
3¼"
3/8" D
5½"
11"
12"
2½"
1"
Pipe Rack & Match Boxes.
1¾"
1¾"
¼"
¾"
¾"
Pattern of Box.
Pattern of Holder.
2"
3/8"
1"
4"
1"
3/8"
6"
4¼"
8"
4"
Whisk Broom Holder.
13.
R.E.W. 1911.

THE ACTION OF OZONE ON AIR

M. O. TROY

Perhaps one of the most universal applications of ozone will be in the treatment of air for the destruction and removal of noxious odors, organisms and emanations. This subject has received some attention in America where the matter of ozone application is a new one, and much attention in Europe, particularly in France, where ozone has long been recognized as a valuable agent of sanitation.

The general consideration of ozone, *per se*, will not be dwelt on here, the subject having been extensively treated in various publications.*

Necessarily what follows must partake somewhat of the nature of a disquisition on the immolation of the bacterial content of the atmosphere; for, notwithstanding the arduous and exhaustive researches of such men as Erklentz and Flügge, Atwater, Heyman, Paul, Dr. Leonard, Hill and others, we are not in possession of a great deal of unquestionable information respecting anything noxious in the atmosphere, with the exception of moisture and bacteria.

Ozone acts on the air as a bacteriacide as well as a powerful agency of deodorization. For the purpose of studying the power of ozone to destroy noxious odors, Scoutettin chose a ward of the hospital at Metz, having a magnitude of about 1,100 cu.m. In this hall he placed two piles of manure about 10 m. apart. These manure piles were permitted to remain for 48 hours, during which period the room became filled with a pernicious odor, indicating an advanced stage of putrefaction, as shown by the evidence of the ammonia evolved.

When this had been accomplished, two vessels of 8 liters capacity were opened in the hall, permitting their contents of ozonized air to diffuse therein. The ammoniacal odor diminished considerably, though it did not disappear completely. The manure was then removed and the experiment repeated. This time the odor disappeared completely and rapidly, the noxious gases, hydrogen sulphide, carbon bisulphide and ammonia having been destroyed.

According to Schoenbein 60 liters of air containing 13 mgs. of ozone will disinfect 324 cu.m. of air. This figure is somewhat equivocal, however, as the quantity required in any given case will depend on the nature and condition of purity of the air.

It will not be out of place to describe briefly the fundamental routine of bacterial culture, the reader being referred to special books on the subject for further details and information.

The various germs differ among themselves in many ways, a most important difference being their growth and behavior on the organic culture media which are used for the purpose of studying them. It is necessary to choose culture media which are habitable by the various germs studied. Briefly the procedure consists in applying the bacteria, which are of microscopic dimensions and totally invisible to the unaided eye, to the surface of a medium on which they can thrive, and in the course of a given period of time to count the number of colonies which have appeared on this surface.

Bacteria proliferate by a process known as segmentation; *i.e.*, they divide at the middle into two smaller cells which grow and in turn divide each into two others, etc.; the process repeating itself continually about every thirty minutes.

The plates consist of shallow glass dishes into which is poured the culture medium, which is permitted to jell in a horizontal position. These dishes, which are called "Petri dishes," have a diameter of from 10 to 20 cm., with straight sides.

The culture medium consists of gelatin, gelose or agar-agar, specially prepared and rendered perfectly sterile before use.

From what has been said of the rapid proliferation of the germs, it will be seen that at the end of a comparatively short time the surface of such a culture plate which has had germs strewn upon it will be shot with colonies of bacteria,

*See article by Dr. M. W. Franklin, *General Electric Review*, Vol. No. 6, June, 1911 the number of these colonies representing the number of original germs, providing they are sufficiently sparse to fall singly. The planting of the germs on the sterile plate is technically called "inoculation."

The experiments of Chappuis on bacteria in air have demonstrated the bacteriacidal value of ozone. He prepared sterile cotton wadding plugs through which air was drawn, and then exposed one half of these plugs to the action of ozonized air, the other half being kept as checks. The plugs collected the dust in the air.

A culture medium of yeast bullion was prepared in some test tubes, and into these were introduced the cotton plugs. The yeast bullion exposed to the ozonized cotton remained clear, while that exposed to the untreated plugs became turbid, demonstrating the presence of numerous micro-organisms in the dust collected from the air. This shows that the germs of the air, or at least those capable of growing on yeast bullion, are destroyed by ozone.

Various experimenters have made tests with the more dangerous disease germs, and De La Coux reports experiments with *bacilli carbonis* (black-leg disease of sheep, cattle and goats) *typhoid bacillus*, *staphlococcus*, *spores of aspergillus niger* and *diphtheria bacillus* in which these germs failed wholly to grow in air containing 1.5 to 2.0 mgs. per liter, *i.e.*, from 0.6 per cent. to 1 per cent. of ozone by volume.

Some experiments have tended to show that ozone does not possess a germicidal action. Prof. Oudin has investigated this subject and has found that if the cultures of bacteria grow deep within the culture medium, the action of ozone seems not to be inhibitive. He has shown, on the other hand, that where a sample of a culture colony, taken from such a deep-seated growth which had previously been exposed to ozone, is from the exposed layer at the surface, no inoculation of a second plate can be obtained.

If the ozone concentration of the air be high, *e.g.*, 8 to 10 gms. per cu.m., the germicidal action will be found to be quite powerful even in deep-seated cultures.

Experiments with cultures of the *tubercular bacilli* have shown that these grow with only one fourth the rapidity of check cultures, when exposed to the action of ozonized air.

These results show that where ozonized air comes in contact with the living colonies their development is impeded; but that when the bacterial colony grows deep within the culture medium, the action of ozone applied to the surface only is less marked, if not altogether imperceptible.

This is what should be expected according to Ohlmüller, who has demonstrated that the bacteriacidal action of ozone is greatly interfered with in the case of colonies growing on organic matter; for the ozone oxidizes the organic medium, thus destroying itself, before it makes sensible its action on the bacteria. Ozone destroys itself in oxidizing organic matter and coagulates albuminous matter.

It may be deduced from the foregoing that any extraneous organic matter found in air, which it is desired to sterilize, will diminish the action of ozone by combining with it; and in consequence, the air should be first filtered whenever practicable. Many failures to produce sterilization in researches on ozonizing air have resulted from the presence of a relatively large amount of organic matter in the air.

Ozone will find an application in the sterilization and deodorization of the air of hospitals, apartments, studios, schools, etc., wherever there is likely to be large crowds.

In stables, chicken coops, toilets and factories, where there are evolved noxious emanations, ozone will greatly ameliorate the conditions. In particular, the shops for assorting rags, manufacture of fertilizers and factories which work gelatin, glue, hides, hair, fat, bones, horn and other slaughter-house by-products, and those which are a source of emanations dangerous to the public health, will find in ozone a powerful ally.

Wherever pure sterile air is of value in the factory, either before, during, or after the completion of the product, *e.g.*, distilleries, breweries, wine houses, etc., the use of ozone should be resorted to.

Experimental installations of ozone apparatus have been made by the engineers of the General Electric Co. for the purpose of studying the applicability of ozone to the purification and deodorization of air under various conditions.

The Art Theater on State Street, Schenectady, a moving picture show, had experienced difficulty with its ventilation. The theater consists of a hall about 30 by 100 ft., and the ventilation is provided by a suction blower capable of aspirating about 90,000 cu. ft. per hour. The management were very desirous of providing the best ventilation possible, as is evidenced by the elaborate and expensive system cited. It was found, however, that notwithstanding the magnitude of the blower, "crowd odors" persisted in the room. The blower was as large as could be used, for anything larger would have produced obnoxious draughts.

As a solution to the trouble, an ozonator was installed above the front entrance to the theater, in such a way as to permit the ozonized air to diffuse into the current of ventilating air drawn toward the aspirator. The instantaneous effect of this was remarkable. The theater has been entirely deodorized and even during the hottest weather of the present summer the air within the theater has been fresh, cool and odorless, excepting for the faint and rather pleasant smell of the slight excess of ozone.

The next case which we may cite provides an even more remarkable instance of the efficacy of ozone in deodorizing obnoxious air, since this case relates to a factory in which, through the nature of the work carried on, emanations are evolved, which constitute a vehicle of certain volatilized diluents and solvents of the varnishes and adhesives used. In a workshop some 50 x 100 ft., upwards of 200 girls are employed in the preparation of various articles of pasted mica. It is easy to realize that the problem of providing clean air under such conditions will always be a difficult one, and in the present instance a considerable expenditure of money and ingenuity was incurred before the correct solution was found. In order to obtain a sufficient supply of fresh air to counteract the effects of the noxious fumes it was necessary at all seasons of the year to have all the windows of the building open to their fullest extent. This plan was feasible during the summer months, but, during the winter, when temperatures below zero were encountered outside, it was necessary to provide a very costly system of heating, in order that the temperature of the room might be sufficiently high to make the place endurable. Many thousands of dollars were also expended in providing draught pipes of large diameter for conducting to the outside atmosphere the fumes diffused by each machine. A point was reached at which it became imperative that some less costly and more efficient system of cleansing the air be adopted, and it was at this point that resort was made to the ozonator.

Two of these were installed and were placed on the center line of the room, each one being some 25 ft. from each of the two end walls. The effect of their action was that during the winter months, the windows, which formerly had to be opened to their fullest extent, required now to be opened only to the extent found necessary in ordinary living rooms. The costly draught pipe system for conducting away the noxious fumes from the machines was removed, and the atmospheric conditions, as far as the comfort of the employees was concerned, were every bit as good as are to be found in any other workshops.

Previously, there were occasions during which the atmosphere became so befouled that the whole staff were compelled to leave their work through general malaise; while at the present time, if through any abnormal condition, such as failure of current supply, the ozonators are unable to operate, the reversion to the old state of affairs is instantaneously noticed.

A third instance which we may quote illustrates the use of the ozonator in purifying the air of buildings which have become burdened with smoke and fumes of combustion. Messrs. Charles Holtzmann & Son are the proprietors of a large store on State Street, Schenectady, for the supply of clothing, furnishing goods, etc., and were recently put to considerable inconvenience as the result of a fire, which broke out in a stable located towards the rear of Messrs. Holtzmann's premises. Clouds of smoke from this fire invaded the clothes store to such an extent that not only were the rooms on the various floors rendered untenable, but the goods with which these floors were stocked became, in many instances, impregnated with the odor of smoke. A delay of several days disastrous to the interests of the management might very easily have been occasioned; but at this juncture an ozonator was installed on each floor with very gratifying results. In the almost incredibly short space of 12 hours the atmosphere of each floor was purified and brought to its normal condition. At the same time the ozone seems to have acted upon the stock which was carried on these floors as a deodorant and fumigator, to the effect that all odor of smoke was immolated. This instance illustrates the utility of the ozonator in directions which up to the present have not perhaps been very generally recognized.

It would be an easy matter to multiply instances affording remarkable evidence of the beneficial uses to which the ozonator may be commercially applied, but the foregoing will probably suffice to give an indication of some of these uses.

In the sterilization of air, the ozone should be blown into the apartment, or the air should be drawn through a special chamber in which the ozone is mixed with it. It is important that the ozone come freely into contact with each individual particle which it is desired to destroy.

The machine for producing the ozone should not produce any *nitrous oxide* or any other gas having an untoward action on the human organism.

The generation of ozone should continue until the air, as determined by experimental test, is thoroughly sterilized, and the machine should produce this result without loading the atmosphere with ozone to an injurious concentration.

The ozonator has been especially designed to meet these conditions. It produces ozone at a concentration of 6.0 mg. per cu.m., and when placed in a closed room the concentration increases with the time, so that the ozonator is suitable for producing ozone proper for breathing or in concentrations powerful enough for producing sterilization.—*General Electric Review.*

THE CONSTRUCTION OF A MISSION TABLE LAMP FOR GAS

C. W. MORRISON

While a number of articles have appeared, of late, describing the construction of several types of arts and crafts lamps fitted with electric light, there are numerous localities whose source of illumination is gas instead of electricity, and for the benefit of such the writer will describe the construction of the mission lamp fitted with a gas burner, shown in the accompanying photo.

The framework of the lamp and shade is constructed entirely of wood, preferably oak, either straight or quartersawed; and as much time and energy can be saved by having the material cut to size at the mill, a material list follows:

1 piece 1⅜ x 1⅜ in. x 3 ft. F4S

1 piece ⅞ x 3 in. x 1 ft. F4S

1 piece ¾ x ¾ in. x 6 ft. F4S

1 piece ¾ x ¾ in. x 6 ft. F4S with a rabbet ⅜ x ⅜ in. cut in one edge full length.

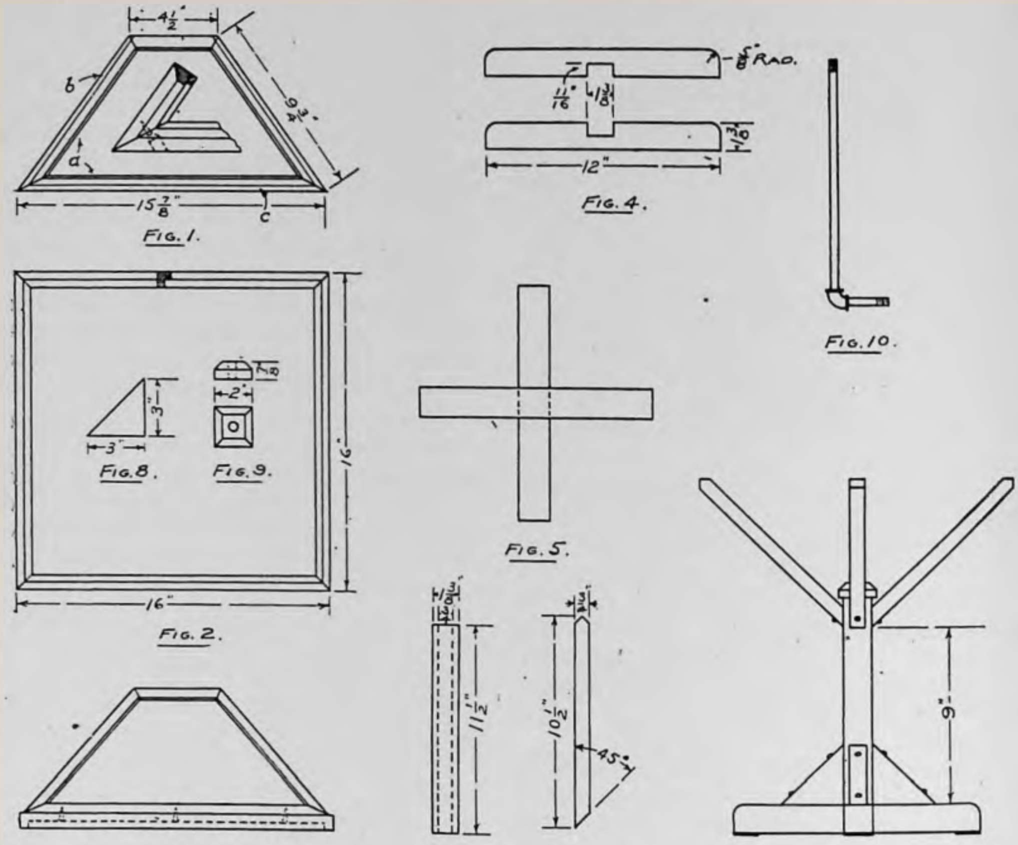


Fig. 1. Fig. 2. Fig. 3. Fig. 4. Fig. 5. Fig. 6. Fig. 7. Fig. 8. Fig. 9. Fig. 10. Fig. 11.

4 pieces ⅜ x ¾ in. x 4 ft. F4S with rabbet ¼ in. wide cut on one edge of wide face ⅛ in. deep.

This will give the material in pieces of sufficient length for the builder to cut to the several lengths as required, with minimum waste.

The construction of the shade will first be taken up, as its dimensions may vary slightly with different builders and in that case the standard can be changed slightly to conform with the shade.

At Fig. 1 is shown one side of shade, one of which can be gotten out of each piece of the ⅜ x ¾ in. material, carefully mitered at the corners, glued and secured by slender screws with heads well let in. As will be seen in the drawing, the pieces are to be joined in such a manner that the rabbet *a* will be unbroken around the inner edge; later, in assembling the sides, this rabbet should be on the inside of the shade and used for letting in the glass from the underside. Make the remaining three sides in the same manner and exactly alike.

After completing the sides it is necessary to bevel the edges of each, *b*, to allow them to be joined properly; about the only way the proper angle can be ascertained is by experiment, and should be found after a few trials; a bevel attachment for the plane will be found very useful for this work after striking the correct angle.

After the sides have been fitted to each other, but before finally fastening them together, try for another bevel on the lower inside edge of each frame *c*, giving each the same bevel, this for the purpose of allowing the frame to set perfectly flat on its lower edge after the four sides have been joined, which may now be done, using glue and small screws to best advantage, countersinking the heads of the screws so they can be puttied before finishing.

Using the piece of ¾ x ¾ in., previously rabbeted, construct the square frame Fig. 2, miter or half lap the corners and secure with screws and glue; the framework described is now to be

fastened to this frame by glue and screws let in from the under side, as in Fig. 3.

The construction of the standard will now be taken up; from the piece of 1⅜ x 1⅜ in. material cut two pieces 12 in. long for the base, Fig. 4; in the center of each cut a notch 1⅜ in. wide ¹¹⁄₁₆ in. deep, from the lower side of one and upper side of the other, joining them by glue in the form of a cross, Fig. 5. Another piece of the same material is cut 11½ in. long and a ¾ in. hole bored through the center its entire length, Fig. 6, to take the gas pipe, Fig. 10.

From the remaining piece of ¾ x ¾ in. cut the four braces 10½ in. long with a 45 degree bevel at one end, Fig. 7.

Cut two pieces 3 in. square from the ⅞ x 3 in. board, saw them diagonally across from corner to corner, which will make four triangular pieces, Fig. 8. From the same material make the small block, Fig. 9, and bore a ¼ in. hole through its center.

This will complete the woodwork, which should now be scraped and sand-papered.

A piece of ⅛ in. gas pipe 12 in. long should now be procured with an elbow and short nipple at one end, Fig. 10; this may be purchased complete fitted with a stop-cock and hose connection; after securing this fitting the lower end of the wooden upright can be cut out to accommodate the elbow and nipple, bringing out the stop-cock at one corner of the upright, close to the base.

With the gas pipe in place secure the upright to the base by means of the four triangular pieces, using glue and blued round head screws. The small block, Fig. 9, should now be placed on top of the upright and fastened with brads and glue. Now the braces are to be fastened to each side of the upright 9 in. from the base, as in Fig. 11. The shade should now fit the upper ends of the braces, the ends of which should easily go into the rabbet in lower frame of shade.

The woodwork should now be given a dark green or brown mission finish, which has been described too often to require repetition.

To complete the shade procure four pieces of green or brown art glass to fit each side of frame from the underside, and secure them by clips and screws, or with brads; a 4 in. glass bead fringe of a color to match glass should be fastened around the lower edge.

Glue four small pieces of felt to the bottom of the base at each corner to prevent scratching the table top.

Horace Greeley used to write a miserable scrawl. One day he sent the following to the Iowa Press Association—"I have waited till longer waiting would seem discourteous, and now decide that I cannot attend your Press meeting next June, as I would do. I find so many cares and duties pressing on me that with the weight of years, I feel obliged to decline any invitation that takes me over a day's journey from home." Out of this the recipients, in consultation assembled, made—"I have wondered all along whether any squirt had denied the scandal about the President meeting Jane in the woods on Saturday. I have hominy carrots, and R.R. ties more than I could move with eight steer. If eels are blighted, dig them early. Any insinuation that brick ovens are dangerous to hams gives me the horrors."

"Did you see the janitor?" asked Mrs. Shivvers.

"Yes," replied her husband. "I told him that it was as cold in our flat as at the north pole."

"What did he say?"

"He merely looked supercilious and asked for my proofs."—*Washington Star.*

THE EVOLUTION OF ARTIFICIAL GEMS*

GEORGE B. HEMING

ARTIFICIAL DIAMOND

The artificial production of the diamond is, in fact, far more complicated than it appears at first sight. If it were only a matter of obtaining the necessary high temperature to fuse the carbon to obtain it in the crystalline condition it would be simple—such high temperatures are readily obtained nowadays by means of the electric furnace and the oxy-acetylene flame—but carbon is one of those substances which pass direct from the solid to the gaseous state under ordinary atmospheric conditions, and only assumes the liquid condition under enormous pressure. The combination of high temperature and enormous pressure can be obtained momentarily by Moissan's ingenious process; but to obtain crystals of any size it is necessary to conduct the operation on a very large scale and to maintain the combined temperature and pressure for a sufficient length of time to allow the liquid carbon to separate out from its matrix; moreover, the entire operation must be conducted out of contact with air, for carbon rapidly combines with oxygen at high temperatures.

Commercially, we are as far from being able to produce artificial diamonds as in the days of the alchemists. It is, perhaps, a bold thing to say that no such thing as an artificial diamond will ever be placed on the market, but one can safely assert that so far as our knowledge stands at present it is impracticable. In saying this, I am quite aware that statements as to the commercial production of synthetic diamonds being an accomplished fact have quite recently appeared broadcast in the public press, but those who are responsible for such statements are, shall we say, under a misapprehension as to the meaning generally conveyed by the term "synthetic," and are unable to follow the distinction I have drawn between an artificial gem and an imitation.

ARTIFICIAL CORUNDUM

To pass on to corundum, the problem of its artificial production is very much simplified by the fact that its composition is oxide of aluminum, and alumina, which is, therefore, its amorphous equivalent, fuses to a liquid under ordinary atmospheric pressure at a temperature somewhere about 2,000 degrees C. (the exact point has not as yet been determined), and being the only stable oxide of a strongly basic metal, it can be heated in air without any change.

The chief problem to be faced, therefore, is that of attaining the necessary temperature, and it is not surprising that crystalline alumina was produced as a scientific curiosity as far back as the commencement of the nineteenth century. It is at this time that we first begin to hear of the oxyhydrogen blowpipe (or the gas blowpipe, as it was then called), and in a book published in 1819, describing various experiments with this new apparatus, we read that "two rubies were placed upon charcoal and exposed to the flame of the gas blowpipe . . . after suffering it to become cold . . . . the two rubies were melted into one bead." This hint does not appear to have been followed up for some considerable time, however, and the earlier experimenters in the production of artificial gems worked in another direction; they were unable to obtain products of commercial utility, because, although they succeeded in obtaining crystalline alumina, it was produced under conditions which resulted in the formation of a mass of small crystals, almost microscopic in size. Moreover, the form of these crystals was that of the hexagonal plate, which is the fundamental form of corundum, and such a form would be useless for cutting even when of considerable area, owing to its thinness. Thus Gaudin, who appears to have been one of the first to attain any success in this direction, obtained a mass of such crystals by fusing alum and potassium sulphate in a closed crucible. Ebelman obtained similar results by fusing alumina with borax, and later Deville and Caron used aluminum fluoride and boric acid. All these attempts yielded similar results, as in each case fusion

*(From an address by Geo. B. Heming, London, Eng.)

was obtained by the aid of a substance melting at a lower temperature which acted as a solvent. Consequently the alumina crystallized out in much the same manner as a salt crystallizes from a saturated solution, and to obtain sufficiently large crystals to be of practical use it would be necessary to conduct the experiment on a very large scale, and subject the fused mass to very slow and carefully regulated cooling.

A STEP IN ADVANCE

In 1877 Fremy and Feil attempted to get over this difficulty by using lead oxide as the flux, and employing a crucible composed of highly acid clay. On heating up the mixture in such a crucible the lead oxide melts and combines with the alumina to form lead aluminate, and on further heating this reacts with the silica of the fireclay, forming lead reacts and setting free the alumina, which crystallizes out. But, although very much larger crystals were obtained by this ingenious process, they had the same form, and were too thin for industrial employment.

Some time earlier than this, however, we hear of the oxyhydrogen blowpipe again, for Gaudin had noticed (as Clarke did in 1819) that by introducing alumina into the flame of an oxyhydrogen blowpipe he could obtain globules of fused alumina similar to the borax beads one makes in the ordinary blowpipe. Gaudin appears to have taken it for granted that these beads were amorphous—that is, an alumina glass—and it was not realized until many years later that they were really identical in all their properties with natural crystalline corundum. When this was realized the commercial production of corundum became only a matter of detail.

Having obtained this further point, the idea immediately suggests itself of converting small and useless stones into valuable gems by fusing them together into one, and, as a matter of fact, "reconstructed rubies"—as stones produced by this method are now generally called—made in this manner were the first artificial gems to be prepared on a commercial scale. These were introduced some quarter of a century ago under the name of "Geneva rubies," and were offered as, and realized the price of, natural stones, until the method of their production became apparent.

It will, of course, be well understood that the experiments I have briefly indicated towards the artificial production of corundum had as their immediate objective the formation of ruby, that being by far the most valuable variety. It had long been known that the color of the ruby was due to a trace of chromium, and by adding a small proportion of potassium or ammonium chromate to their mixture, Fremy and Feil reproduced accurately the color of the ruby in their crystalline flakes.

RECONSTRUCTED RUBIES

The process of producing reconstructed rubies by means of the oxyhydrogen blowpipe is, roughly, as follows: The residue from cutting rubies and small worthless stones is broken into coarse sand, a small quantity of which is placed on the center of a disc of platinum; this is then carefully brought to the fusion point, care being taken at this stage not to raise the temperature to such an extent as to melt the platinum support. As soon as this mass is fused it serves to protect the platinum, and the reconstructed ruby can be built up on it by adding the fragments of ruby one at a time by means of small platinum forceps. These pieces have to be dropped on with great care in order to secure incorporation with the mass and prevent as far as possible the formation of air bubbles. It will be readily understood that this process is a tedious and laborious one, and, in fact, the formation of masses of sufficient size to yield large stones on cutting is a matter of such difficulty that the cost of production is very high.

Just about seven years ago, however, Verneuil overcame this restriction when he hit on the extremely ingenious idea of introducing the raw material through the blowpipe, and thus placing it on the support automatically. The blowpipe is arranged vertically over a small insulated chamber containing the support on which the mass is to be built up. The oxygen tube communicates at its upper extremity with a funnel-shaped hopper, in which is suspended a small sieve filled with the raw material, which is rhythmically shaken by means of a small hammer actuated by an electro-magnet or cam. Each time the hammer taps the support of the sieve, causing it to vibrate, a small quantity of the powder falls through the tube below, and, carried along by the gas, passes out at its lower extremity into the zone of flame, where it is immediately raised to the fusion point, and falls as a melted globule on the support below. This support is arranged with a screw adjustment, so that as the mass of corundum is gradually built up by the constant addition of fresh globules the surface can be kept at a constant level, and the portion already formed removed from the zone of heating so as to allow it to stiffen. When the apparatus is first started the blowpipe is adjusted so as to give a comparatively cool flame, and the powder is admitted slowly. By this means a small "stalk" is formed, which insulates the mass from the support and prevents the fusion of the latter. When this has been formed the full pressure of the blowpipe is put on and the rate of admission increased, with the consequent formation of a "boule," as it is termed, having the shape of a pear.

With this apparatus a boule, weighing some 20 to 30 carats, and capable of yielding two cut stones of about 6 carats each, can be prepared in about half an hour almost automatically, a single operator being able to control several machines. The boules, on cooling, very often split in half in the direction of their growth, and this is a convenience rather than otherwise, as the resulting shape can be cut to greater advantage.

In the first instance reconstructed rubies were made in this way after the manner introduced by Gaudin, the material fed into the blowpipe being pulverized rubies and chips, and this method is still employed by some workers. But more commonly nowadays the corundum is produced direct from amorphous alumina by using pure ammonium alum as the raw material. On reaching the flame this decomposes, the ammonia and sulphuric acid volatilizing, leaving the alumina. Stones made by this process are generally known as "synthetic," as distinct from "reconstructed," although, of course, to be pedantic, the process is one of decomposition rather than synthesis.

SYNTHETIC CORUNDUM

The "synthetic" corundum produced in this way, if pure ammonium alum is used, is, of course, colorless, and can be used as artificial white sapphire. If a small proportion of chrome alum is added the resulting stones are rubies, and other colors may be produced in the same way. For a long time all attempts to reproduce the fine blue of the sapphire failed, because, following the apparent analogy of silicates, cobalt was invariably employed as the coloring agent. This, however, does not readily form an aluminate in the same way that it does a silicate, and, in consequence, it is impossible to produce a satisfactory coloration in the corundum by its means; it is possible to get the cobalt in a state of combination by adding a large proportion of magnesia to the alumina, but then the product formed is not a crystalline alumina but magnesium aluminate, and its properties are fundamentally different. Its refractive index is lower, its refraction single, and its hardness lower. In fact, the result is blue spinel instead of sapphire. Moreover, such blue stones have the characteristic absorption of cobalt, and appear purple in a light that does not contain a large proportion of blue rays.

In 1908 Paris attempted to avoid this latter difficulty by preparing a calcium aluminate colored with cobalt, as it is found that in this case the transmission of the red rays is less pronounced. But the calcium aluminate so formed is not crystalline at all, but amorphous. A year or so ago, however, the problem of producing synthetic sapphire was finally solved by the use of titanium oxide, a very unexpected result, considering the chemical position of this element. With this last advance the artificial production of the corundum gem-stone may be considered to be completely solved, and cut stones can now be obtained in every variety of color, from pure white to ruby and sapphire, at prices ranging from $1.00 to $2.50 a carat, according to color, quality and size.

INTERESTING GEMS

Whatever may be their economic importance, a very much debated question, there can be no doubt as to the scientific interest of this group of artificial gems. In the first place it is a matter of some interest that a mass of fused material formed in this way should not only be crystalline but possess all the characteristics of a single crystal. Crystallographers are agreed that each boule is a single crystalline individual, with the axis roughly perpendicular to the plane of formation—that is to say, running from the point of attachment of the pedestal to the top of the mass. On the top of the boule one invariably finds a mass of symmetrically arranged facets, which Dr. Herbert Smith has found to correspond with the fundamental rhombohedron or corundum. Judging by analogy with other materials, one would expect at first sight that a fused mass formed in this way would be either a heterogeneous mass of minute crystals, or entirely amorphous, possessing the structure characteristic of glass. It is well known, for example, that under similar conditions pure silica yields "quartz glass," which is extensively manufactured at the present time. One is tempted to dwell upon this point, and discuss its bearing on such matters as the devitrification of glass, but it would be entirely out of place to do so in the present paper.

Then, again, there is the matter of coloration. One would like very much to know what is the state of combination of the chromium in a ruby, and whether the color is produced by chromium aluminate in solution or metallic chromium in molecular suspension. In glass, as is now well established, this color is produced by the optical effect of ultramicroscopic spheres of metallic gold or copper, but there seems to be no parallel between the two cases.

ANOMALOUS COMBINATION

A point of more practical interest is the fact that although the artificial corundum is a true crystal, it possesses the shape and formation of a congealed liquid or glass. The practical interest of this lies in the fact that it affords the only means of distinction between this artificial corundum and the naturally formed gem stone. Being of exactly the same composition and crystalline structure as the natural mineral, it cannot be identified by any of the physical tests I briefly referred to above. For all practical purposes the artificial ruby *is a ruby*, and one can only deny that it is a "genuine ruby," if this word is held essentially to connote a product found in the earth and not made by man.

And yet, owing to the curious anomaly of its structure, the artificial product can almost invariably be distinguished from the natural with the greatest ease. In the naturally formed stone any foreign matter which may be present is coerced into following the lines of growth of the crystal, and more particularly bubbles of gas which may be present in the liquid are distorted from their natural shape so as to accord with this symmetrical growth. It is the great exception to find a natural ruby entirely free from such inclusions, which generally form irregular cavities with a decided tendency to geometrical shape.

The Way You Walk

There is a new science appearing on the horizon. It has yet no name, but it claims to surpass graphology and chiromancy in delineation of character.

It is based solely on the manner of walking. People who take short, quick steps and whose feet hardly touch the ground are superficial and inconstant.

On the other hand, those of us who take long, regular strides, have well ordered minds.

Thanks to the fashion of 1910, which cuts off more and more of skirt widths, more of us will have to be classed in the first category.

One is obliged to take short, tottering steps, and so the new science will conclude that we are inconstant and superficial.

Let us make the best of it and pray that our feet may be as light as our mentality is supposed to be.—*Duluth News-Tribune.*

Birdmen are not quite up to the standard of harmony adopted by the birds in their nests.—*Birmingham Age-Herald.*

THE DISAPPEARANCE OF LIEUT. BAGUE

AUSTIN C. LESCARBOURA

Among the numerous calamities which have marred the splendid progress made in aeronautics and aviation, probably none are more pathetic than that of Lieut. Bague, of the French Army, who essayed to cross the Mediterranean Sea from Nice, France, to Algeria, a distance requiring six hours of steady flying to accomplish. No doubt, the accomplishment of such a wonderful flight would have placed Lieut. Bague at the front of the foremost aviators. As it is, he departed from Nice, and never was heard of again. The story is interesting, and we will give the many details gathered from various sources.

This heroic, though imprudent, aviator had for a mount the latest type of Bleriot monoplane, fitted with a 50 h.p. Gnome power plant. It was fitted with every accessory capable of adding to the facility of making such a long journey. Among these was a special compass, made especially for aeroplanes, and which was set in front of the pilot to guide him on his way. He also carried a flock of carrier pigeons, similar ones to those used in the French Army, and some have thought it strange that these birds did not bring back tidings. It is well known, how ever, that at that season of the year, the pigeons do not travel back to their homes, and are of little if any value in that respect. A few weeks previous, Bague had surprised the world by flying over the sea to a small island, Gorgona, off the Italian coast, covering, in a straight line, a flight of 125 miles entirely over water. This constituted a world's record for over-sea flight.

At the end of his first flight Bague said: "I was alone above the sea; never had it appeared so vast and so deserted. At the end of a short time, I encountered a new difficulty. I had an uprising wind, which made me lean and prevented me from advancing. My speed was reduced to half. I received a shower of oil, such as I had never received before, my glasses became entirely useless, being rendered entirely opaque with the oil. Leaning in front, I had great difficulty in reading the compass; I had difficulty in seeing the direction of the points on the face of the compass, and I was advancing desperately slow. This situation menaced to become eternal, and I was already thinking of the splendid vol-plane which I would make at the end of my six hours. Like a bird, I would then gently lie on the surface of the sea. I would stay until the aeroplane sunk, dragged down by the weight of the motor and the water which would wet the wings. And then, my life belt at my waist, I would take a pretty lesson in swimming."

Poor Bague! He had predicted his own death; and it is more than pathetic to see the feeling he had towards his monoplane. It was more than a machine to him, and he looked at it in the same light as he would have seen an animal. He said, after landing at Gorgona on his first voyage:

"Be quiet, we know each other better now; we both know what the sea is, and I promise you that the next time we will be happier and that it will be successful."

His second attempt was made on June 5th, 1911, and all searches for the machine or the aviator have proved fruitless. Torpedo boats have scoured the sea in all directions and have failed to find any trace of the unfortunate aviator. He was last seen by a fisherman, who says that he appeared to be flying very fast, but at a low altitude. He watched the aviator, until he disappeared behind the horizon. According to the fisherman, he was taking a wrong direction, which would bring him further out into the wide sea.

The last words of Bague were addressed to his friend, a fellow lieutenant in the Army, and were: "This time, old man, I think I will accomplish it." The friend watched him from the roof of a house with a pair of powerful field glasses until he was seen to disappear over the horizon. This was the last ever seen of the brave and perhaps over-daring aviator Bague, who met the same fate as the unfortunate Cecil Grace.

A CHEAP AND EFFICIENT EMERY GRINDER

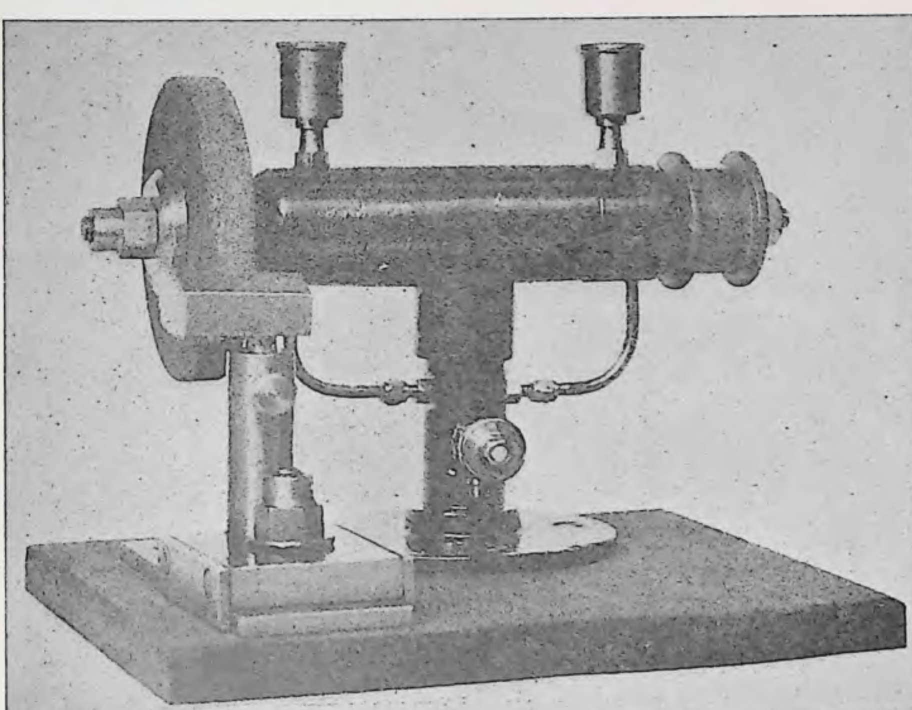
A. R. GRIGGS

The following is a description of a small tool grinder I designed and made about a year ago. The machine is mounted on my lathe stand and driven off the flywheel by a flat belt, at a speed of from 2,000 to 3,000 r.p.m., says *Model Engineer*.

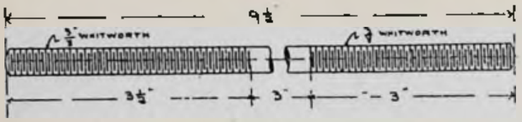
The body of the grinder was built up of standard gas fittings, as will be seen in the accompanying drawings. A 1-in. tee, with a ¾-in. branch was first procured, and the 1-in. threads at each end cleaned out with a standard plug tap. Two mild steel plugs were then turned up to the dimensions shown on the drawings, and threaded 1 in. iron pipe size, so as to screw in the 1 in. branches of the tee without shake, 5/16 of their length being left projecting out at the ends for the 1-in. caps to screw on. A small flat was filed on the thread at the back end of each plug for a 3/16 in. setscrew to bear on, so as to lock these plugs always in the same positions. The position of these setscrews is shown on the drawings.

Now the tee, with the plugs in position, was mounted in the lathe, and a 7/16 in. hole drilled centrally through both plugs. They were then taken out, each mounted on a mandrel, and a cup turned on the outside face, to a radius suitable for ¼ in. diameter balls. After the cups were carefully case-hardened they were replaced in the tee in their correct positions, and the setscrews tightened up, By this method accuracy in the alignment of the holes and concentricity of the races was assured. Two cast steel cones were then turned up to the correct radius and size shown on the drawings, drilled and tapped ⅜ in., care being taken to get the thread true with the ball race of the cone, and then carefully hardened.

The spindle was turned from a bar of tool steel, and is ⅜ in. diameter, being screwed ⅜ in. at each end, to a distance shown on the drawings. The spindle was now ready for mounting on its bearings for testing the accuracy of the ball races. After the balls had been placed in position, the cones were screwed down on the spindle until there was only the slightest perceptible shake;



General View of Completed Emery Grinder



TOOL STEEL SPINDLE
1 OFF

they were then locked by means of ⅜ in. lock nuts.

Two 1 in. caps, having their ends drilled ⅜ in. clearance, were then screwed on to the ends of the plugs, until tight up against the ends of the tee, thus effectually shielding the bearings from all dust and grit.

The spindle is fitted with a turned hardwood pulley at one end, 1½ in. diameter on face and ¾ in. wide between flanges, to take a ⅝ in. flat belt. Wood was chosen for the pulley, because of its superior gripping power, as it was necessary to keep down the diameter to obtain the required speed from the lathe fly-wheel.

The pulley is clamped between two nuts, the inside one being circular and let into the side, thus keeping the pulley a minimum distance from the bearing.

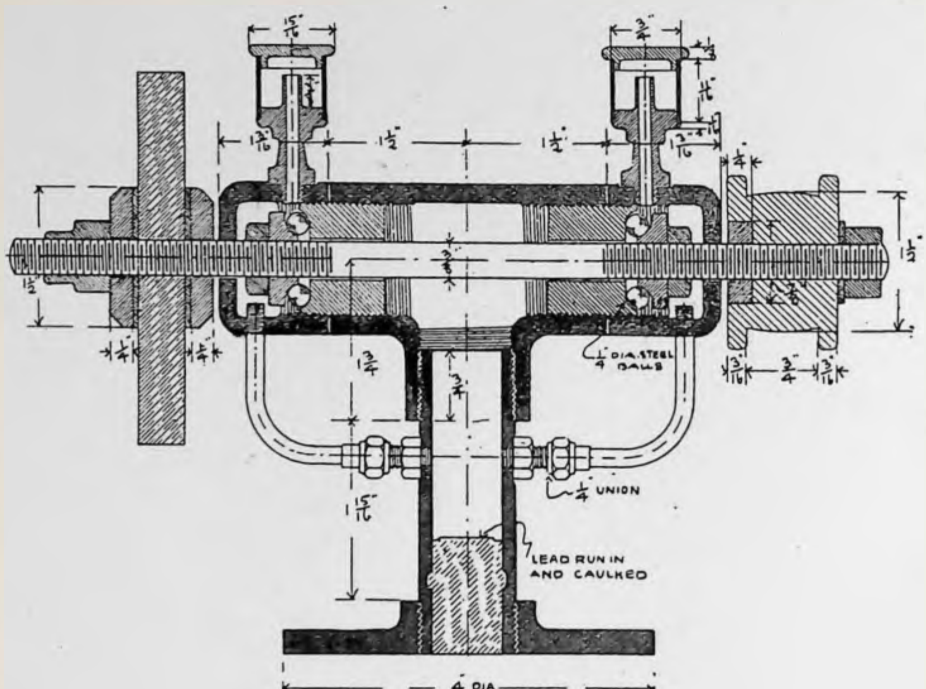
To the other end of the spindle the grinding wheel is attached, being clamped between two leather-faced washers of steel. The inner washer is drilled and tapped ⅜ in., while the outer one has a ⅜ in. clearance hole drilled through it.

In my case I am now using a carborundum wheel for tool grinding, and find its cutting and lasting qualities excellent when run at the correct speed, as stated by the makers. I have also various sizes and grades of emery and alundum wheels, which I use on this machine when occasion demands.

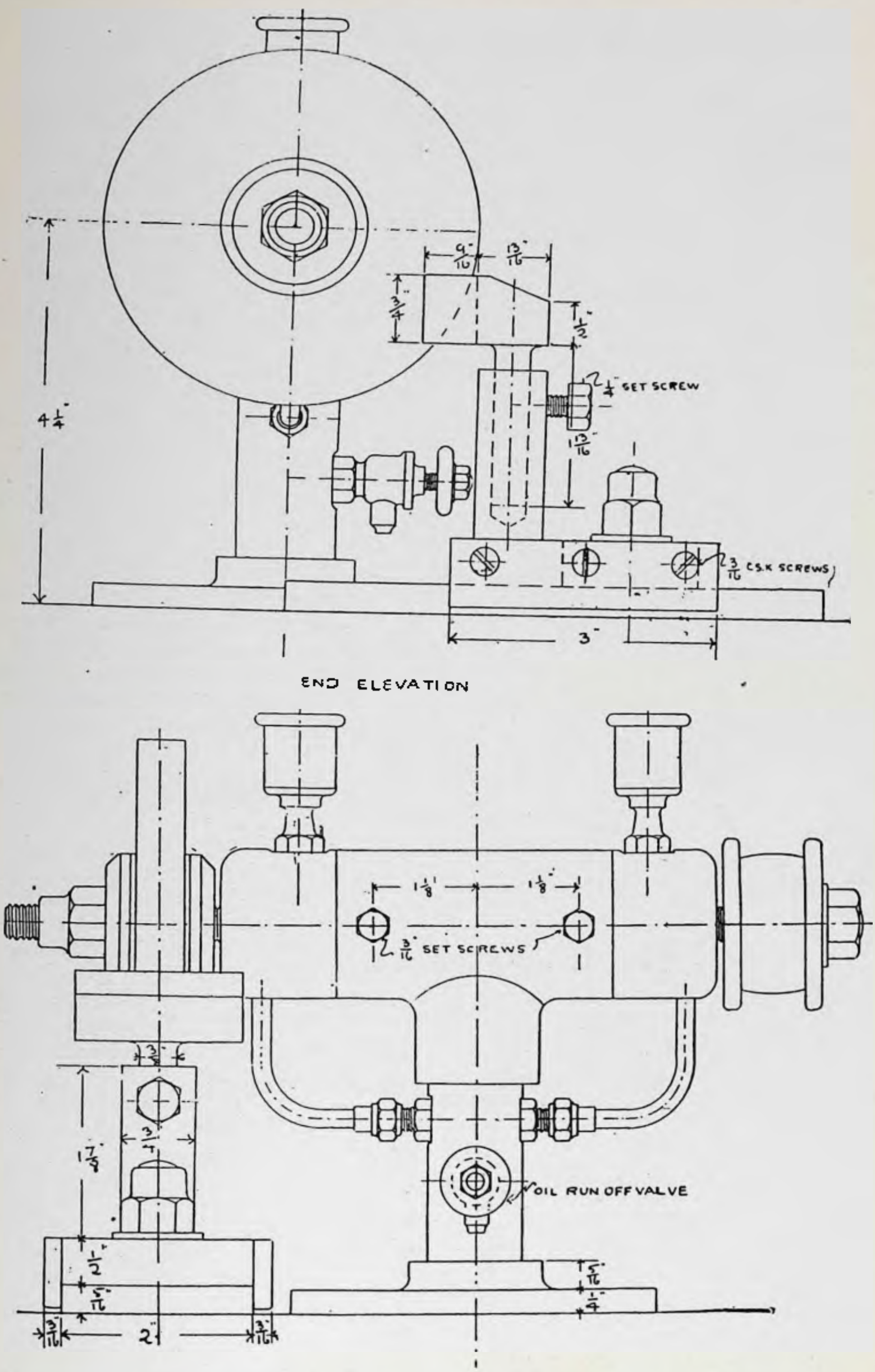
To complete the machine, a short length of ¾ in. steam tube was screwed both ends, and a 4 in. diameter standard flange screwed tightly on one end. This bottom end was then run with 1¼ in. thickness of lead, a ring being turned on the inside of the pipe to act as a key for the lead plug, which was afterwards caulked up to make an oil-tight joint. The other end of the pipe was securely screwed into the ¾ in. branch of the tee, thus providing suitable means of fastening the machine down.

Siphon lubricators have been provided for each bearing. These were built up of brass rod and tube, and turned and polished all over. They are fitted with lids to prevent any dust reaching the bearings.

The interior of the ¾ in. upright pipe

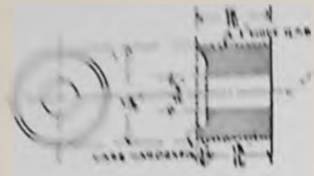


LONGITUDINAL SECTION



FRONT ELEVATION

Two Views of Emery Grinder



STEEL BALL RACE
2 OFF

STEEL CONE
2 OFF

forms a waste oil chamber, to which [illegible] in. outside diameter copper pipes are led from the bearing chambers to carry away the surplus oil. It will be seen by the drawings that the pipes are allowed to project through into the interior of the bearing chamber, so as always to maintain a small oil bath, into which the balls just dip, so that it is not necessary to put the lubricators into action for short periods of grinding only.

A small run-off valve is provided at the bottom of the waste oil chamber, so that the oil may be withdrawn from time to time.

An adjustable tool rest is provided for grinding tools, etc. It was simply made out of suitable steel plate and bar as follows, castings not being employed at all:

A piece of steel plate $6 \times 2 \times \frac{5}{16}$ in. was first cut out and filed up true and drilled and tapped for a $\frac{3}{8}$ in. stud, which was screwed and riveted in. Another piece of plate, $3 \times 2 \times \frac{1}{2}$ in. slides on top of the above, being provided with a slot for the $\frac{3}{8}$ in. stud to pass through. To the sides $\frac{3}{16}$ in. steel plates were secured, with countersunk screws, to guide the top plate in its travel, and at the front end a turned steel column was screwed and riveted in. This column has a $\frac{3}{8}$ in. hole drilled down its center into which various sized tool grinding tables can be slipped, and then secured by a $\frac{1}{4}$ in. setscrew. The slot provides means of adjusting the table to different sized wheels.

This completes the description of the machine, which, with the aid of the drawings, I hope I have made sufficiently clear. I may say that since the machine was first put to work some twelve months ago, the bearings have not required the slightest attention besides oiling, and are exactly the same fit as when first put to work, although the machine has had a good deal of heavy grinding to do.

INHERENT SPEED REGULATION OF THE DIRECT-CURRENT SHUNT MOTOR

E. W. SHORT

It is customary to consider the direct-current shunt motor as a machine which runs at constant speed when supplied at constant terminal voltage, and of which the steady speed may be varied only by the use of a regulating resistance in the shunt field circuit, says *The Electrician*. That this assumption is not strictly correct, and sometimes not even approximately true, was brought to the author's notice some time ago in the course of testing a number of direct-current shunt motors driving textile machinery. The speed of the motors tested was nominally constant within 1 or 2 per cent., but on account of the intermittent nature of the load on the motors, though they were not overloaded, the actual speeds showed very considerable variation from constant value.

To summarize briefly the conclusions arrived at as a result of the tests referred to, it appears that although a direct-current shunt motor may be so designed, and its voltage drop and brush position may be so adjusted, that it runs at the same speed on no load and on steady full load, at any given temperature, yet the speed of the same machine will vary very considerably when working on a rapidly varying load such as is often met with in industrial conditions. In short, the tendency of a shunt motor to maintain perfectly even speed under all conditions, which might be called its inherent speed regulation, is sometimes not so good as might be supposed. Even if the motor is differentially compounded for perfect speed regulation for all steady loads within the usual limits of output of the machine, or if interpoles are added to allow greater latitude in the brush position or in the working range of the flux, the particular correction which is adopted disappears when the motor is worked on a rapidly varying or intermittent load, and the speed variation may be of considerable importance.

The results obtained by the employment of the electrical drive with continuous-current motors were unsatisfactory from the textile point of view. The discrepancies between the actual results obtained from the drive and those which it was reasonable to expect could be obtained, were both important in amount and serious in their consequences; neither the amount nor the quality of the work produced on the textile machines was as good as would have been obtained by driving at constant speed.

The steady full-load speed of a direct-current shunt motor depends also upon the position of the brushes on the commutator. Rocking back the brushes from the neutral position causes the full-load speed to rise, thus making available for non-reversing motors a means whereby the decrease in speed on load due to voltage drop may be offset, and the steady speed maintained approximately the same at no load, full load and intermediate loads. With a view to obtaining the closest speed regulation when using shunt motors, even on steady loads, it is thus of great importance to adjust the position of the brushes carefully, not only with reference to the non-sparking position, but also with reference to the speed. If sufficient backward lead cannot be given to the brushes to obtain the same steady speed from no load to full load, or if it is necessary to keep the brushes in the neutral position for reversing or for other special reasons, a differentially compounded field may be employed. In this case, the shunt field coils must be designed to provide the full ampere-turns necessary to set up the maximum flux, which is at no load. Instead of rocking the brushes and utilizing the demagnetizing effect of the armature back ampere-turns to reduce the flux at full load, the brushes can be kept in the neutral position and the series coils designed to provide sufficient demagnetizing ampere-turns, when full-load current flows, to reduce the flux, the amount of reduction being proportional to the difference between the back e.m.f.'s at no load and full load.

Although, however, any given motor may be arranged by rocking the brushes or by differential compounding, to regulate perfectly on slowly varying loads, quite other effects show themselves when the load is quickly intermittent or rapidly varying. This is due to the mutual induction between the shunt and series field windings, or between the armature and shunt field windings. When series and shunt windings are wound on the same pole, the direct effect of the mutual inductance existing between the two sets of coils is that any change in the current in the series coil either tends to produce a momentary current in the shunt coil, if no current flows in the latter to begin with, or affects momentarily any current which may already be flowing in the shunt circuit. It follows that the magnetizing or demagnetizing effect of a compound winding is not effective immediately the series current flows, since any change in the series ampere-turns is accompanied by a momentary change in the shunt ampere-turns, in the opposite direction, so that for the moment the total of the effective ampere-turns acting on the pole is unaltered, and the flux is also unchanged. In the case of the differentially compound motor, when full load comes on, the flux in the poles is not immediately reduced to suit full-load conditions, and if the duration of the transient conditions is sufficiently long, the speed of the motor will have time to drop considerably before the flux has attained its steady value. The contrary effect takes place when full-load current goes off the motor. If variations in load are rapid and succeed each other quickly, the speed may vary constantly up and down as the load decreases and increases. If the motor is not differentially compounded, but the regulation depends on the demagnetizing action of the armature back ampere-turns, the effects will be practically the same. Any variation of the armature current will cause a momentary and contrary change in the shunt exciting current, and the speed of the machine will usually have time to vary up or down before the exciting current and flux have time to settle down to steady conditions.

The behavior of a 35 h.p. motor, particulars of which are given in full in the Paper, on a rapidly varying load is now considered; in calculating the mutual inductance of the motor windings, the author has followed the method applied by Mr. C. P. Steinmetz to the conditions existing in a compound generator.

Calculations show that on this machine the shunt current increases when the speed changes from its normal value of 0.87 ampere to 0.96 ampere, nearly, in the same time that the main current in the series coils grows from zero to 59 amperes—that is, in 0.05 second. The practical result of the delay in the adjustment of the shunt exciting current to those steady conditions where the effects of voltage drop and differential compounding are balanced, is that the speed must drop to reduce the back e.m.f. and allow full-load current to flow, unless the armature has sufficient flywheel effect to keep the speed at nearly normal value. Since the flywheel effect is usually inadequate to maintain full-load torque for a sufficiently long interval, however, the speed drops, and full-load torque and current only maintained at the lower speed. If the motor is running at steady speed and full load is suddenly taken off the opposite cycle of events takes place. The speed rises quickly, and the sudden decrease of the main current in the series coils now has the effect of causing the shunt current to alter also.

The effect of running this motor on a load which increases from almost no load to full load is that the speed drops about 2½ per cent. below normal, and every time full load goes off the speed rises about 2½ per cent. above normal. This assumes that the steady conditions are regained on each occasion before the next alteration in load takes place. If the load is regularly put on and taken off the speed varies up and down about 5 per cent. continuously. Continuous oscillation of the speed between its extreme values will occur if the machinery driven by the motor offers a periodically varying load torque opposed to the driving effect of the motor. This occurs when driving looms in a textile mill, or a machine tool of which the motion is reciprocating or the cutting intermittent. The speed change depends upon the amount of the load change, and is not affected materially by the original value of the load, whether this is no load or full load or other value.

ELECTRICAL COMPUTATIONS

Everyday Figuring on Engine Room Problems

While the usual manipulations of electrical machines is a matter of common knowledge in the engine room, says *Practical Engineer*, there is some figuring required which is found bothersome, and some relations between values that are not entirely clear in the minds of all engineers; which is the reason for the present explanation of examples.

Practically all examples start with current and voltage and between these there is the same relation as between volume flowing per minute and pressure in a steam or water pipe.

Volume of steam per minute, measured in cubic feet times pressure per square foot gives power delivered; so current times voltage gives power delivered. But in the electrical problem our units, the ampere, the volt and the watt have been made for convenience so that 1 ampere x 1 volt = 1 watt, whereas 1 cu. ft. of steam per minute x 1 lb. per sq. ft. = 1/33,000 of an h.p. To get the power in an electric circuit, therefore, multiply the amperes by the volts and it gives the watts; and to reduce this to h.p., divide by 746.

LOAD ON A DYNAMO

For instance, on a switchboard the readings are, voltage 118, current from one dynamo 320 amperes, from the other 576 amperes, the first being a 50 kw. capacity and the second a 75 kw. What percentage of its capacity is each machine carrying?

The first is doing 118 x 320 = 37,760 watts; or as a kw. is 1,000 watts, it is doing 37,760 ÷ 1,000 = 37.76 kw. And this is 37.76÷50=0.755 or 75.5 per cent. of its rating.

For the second dynamo the power is 118 x 576=67,968 watts or 67.97 kw.; and this is 67.97÷75=0.906 or 90.6 per cent. of its rated load. The big dynamo is, therefore, carrying more than its share of the load which makes little difference so long as both are underloaded, but would not be good policy if both were heavily loaded.

EFFICIENCY OF GENERATING UNIT

Suppose that the engine driving the larger machine is indicated to develop 108.5 h.p., what is the efficiency of the generating unit?

The watts were found to be 67,968, and dividing this by 746 gives 90.8 electrical h.p. and the efficiency will be 90.8÷108.5=0.838 or 83.8 per cent.

SWITCHBOARD EFFICIENCY

This ought, of course, to be very nearly 100 per cent. in a well designed and built apparatus, but cases have been known where overloading the bus bars or loose connections have made the loss in the board considerable.

To get its efficiency, the total power delivered to the leads is divided by the total power received from the generators. In our problem, current is supplied to the following circuits: fan motors 127 amperes, hoists 37 amperes, mill motors 398 amperes, lights 333 amperes and a testing voltmeter shows 118.17 volts at the terminals of the generator leads and 117.98 volts on the buses at the distributing panel.

Adding the delivered currents gives 127 + 37 + 398 + 333=895 amperes, and this times 117.98=105,592 watts. From the generators there comes 320 + 576=896 amperes, and this times 118.17 =105,880 watts, and the efficiency will be 105,592÷105,880=0.9973 or 99.73 per cent.

WIRE SIZES

When alterations or additions are made a frequent question is, "What size of wire shall we use?" It must, of course, carry the current without overheating, but the size is more often decided by the allowable loss of energy or of voltage in the circuit. Smaller than No. 14 wire must not be used because it is too weak mechanically. For main circuits 5 to 10 per cent. loss is allowed, depending on the length of the circuit. For taps 1 to 2 volts loss is permitted.

As an instance, a circuit for lighting is to carry 40 16 c.p. lamps, the main line being 150 ft. long and the taps each carrying 4 lamps to be 20 ft. long. For 110 volt lamps, a reasonable allowance is 8 volts in the circuit and 1½ volts in the taps.

For the carbon filament lamps, each one will use 55 watts so that 40 will take 55 x 40=2,200 watts at the lamp; since amperes x volts=watts, watts÷volts will give amperes, and 2,200÷110=20 amperes required.

To determine the size of wire we make use of Ohm's Law that resistance=voltage÷current. In case of a circuit the voltage is the loss allowable or "drop" and 8÷20=0.4 ohms, the resistance of the main circuit. This is for both wires or 300 ft., and to get the resistance of 1,000 ft., the value usually given in wire tables, we divide 0.4 by 300 and multiply by 1,000. This gives 0.4÷300 x 1,000=1.333 ohms. The table of values for copper wire shows that the resistance for No. 11 is 1.269 and for No. 12 is 1.601 ohms; but the odd numbers are not used commercially, and resistance of No. 10 is 1.01 ohms. Either one will safely carry the current, so whether to let the loss be more than 8 volts and use No. 12 or less and use No. 10 depends on the taps.

To figure these, 4 lamps will require 4 x 55=220 watts or 220÷110=2 amperes, and the drop allowed is 0.5 volt, so that 0.5÷2=0.25 ohm resistance for the taps. This is for 40 ft. and 0.25 ÷ 40 x 1,000=6.25 ohms. Resistance for No. 18 wire is 6.57 ohms per 1,000 ft. but No. 18 is not permitted, so No. 14 would be used, and as this will cause less than ½ volt drop, more than 8 volts may be allowed in the circuit; hence, No. 12 wire would be used.

It is interesting to note that if tungsten Mazda lamps be used, the same light may be had by using three 25 watt lamps in each of the 10 clusters. This would call for 30 x 25÷110=6.8 amperes for the circuit and the resistance would be 8÷6.8=1.177 ohms, or 1.177÷300 x 1,000=3.92 ohms per 1,000 ft., which is smaller than No. 15 wire. The whole

(Concluded on page 279)

EDITORIAL

We are glad to reprint the following from the *Boston Post* of August 31, 1911, and have no doubt that many readers will share our feeling of admiration for the bravery displayed by young Mr. Sheesley:

SAVED BY BOY

Twelve passengers, a steward and three negro employees of the wrecked steamship *Lexington*, of the Merchants and Miners' line, were brought to Charleston today by the revenue cutter *Yamacraw*, which left the captain and crew of forty-three on board. All give the credit for rescue to a nineteen-year-old boy, the wireless operator.

During the fight of the vessel against the storm two firemen are reported to have been burned to death and a third terribly scalded. The steamship has her nose imbedded in quicksand off Huntington Island, at the mouth of the Edisto river, and it is said that she will be a loss.

The *Lexington* was bound from Savannah to Philadelphia. For twenty-four hours the ship battled desperately against the hurricane, finally being driven aground, where the tremendous waves smashed violently against her, and where the powerful wind tossed her perilously about. Three times the vessel was covered with green water, the pumps expelling enough to clear the upper portions and float the stern.

CLIMBS INTO RIGGING

But for the heroism of the wireless operator, Sheesley, there would have been no chance of rescue. After the storm had wrecked the boat's wireless station, Sheesley climbed into the rigging and adjusted his instruments, flashing the calls for help. The signals were caught by the *Yamacraw*, which hastened to Huntington Island.

Sheesley, who is only nineteen years old, was in imminent peril of his life while operating the wireless, the wind almost tearing him from his insecure position. The lad was utterly exhausted by his desperate work.

Passengers incessantly prayed for abatement of the storm and when the government steamer hove in sight a mighty cry of relief went up from the sorely stricken persons on the *Lexington*. When the captain realized the danger of the liner breaking up at any moment he had life preservers strapped to every passenger.

On October 2, 1911, the doors of the big Mechanics Building in Boston will open to admit the public to what promises to be the greatest Industrial and Educational Exposition ever held in New England. The purpose of the big fair is to promote manufacturing and commercial activity in New England; to show the people the methods and extent of our manufactures and resources; to bring the employer and workman, merchant and buyer, into closer touch with manufactory and its products; and to stimulate, particularly the younger generation of the people, to a realization of the dignity and possibilities of a trade, and thus promote industrial education.

We shall be glad to welcome our many New England readers and subscribers at our exhibit which will be found immediately to the right of the main entrance in Grand Hall, in spaces 44 to 46 inclusive. Come and get acquainted.

Our November number will contain two notable articles on telephony, "The Wonderful Telephone," by B. Lloyd Davies and "Cable Splicing," by Geo. M. Peterson. The former treats of the principles of exchange wiring and operation in a non-technical but nevertheless very comprehensive manner. The latter article will undoubtedly prove interesting and helpful to those who are engaged in telephone construction. In it may be found many practical hints and valuable suggestions. In addition to these two articles, the usual departments and a particularly strong selection of general material will contribute to the production of a most interesting number.

We wish to impress upon our subscribers the importance of immediately notifying us of any contemplated change of address. Just at this particular season of the year, many readers are returning from vacations or otherwise making a change in their place of residence; and to aid us in avoiding confusion and delay, we again request such readers to advise us as far in advance as possible. The postal authorities will not forward mail of this description and the inevitable result is that the magazines are returned to our office, where postage must be paid, and the subscriber is subjected to an annoying delay in the receipt of his magazine.

Through an error, which was not discovered until the form had gone to press, the halftone illustration Fig. 3 of the moon on page 242 of this issue was placed upside down, in part of the edition. The two pictures of the moon should face in opposite directions.

Electrical Computations

(*Concluded from page* 277)

system could therefore be made No. 14, more convenient as well as less costly. In addition there will be less expensive fixtures, more lights can be run from the dynamo and the power required is reduced both for lighting the lamps and for loss in the wiring.

MOTOR WIRING

For a motor at 750 ft. from the switchboard, a 10 per cent. drop is allowed. The power required to drive the fan is 7 h.p. and the motor is wound for 530 volts and has an efficiency of 92 per cent. Switchboard voltage in the engine room is 550.

To get the current needed, it is necessary to find the watts taken from the line by the motor; and 7 h.p. delivered, at 0.92 efficiency will require $7 \div 0.92 = 7.61$ h.p. which at 746 watts each gives $7.61 \times 746 = 5,677$ watts. Divide this by the voltage 530 and $5,677 \div 530 = 10.7$ amperes.

Loss in voltage will be $550 - 530 = 20$ volts, and this divided by current will be the resistance allowable in the circuit. $20 \div 10.7 = 1.87$ ohms. This is for a length of twice the circuit or 1,500 ft. and $1.87 \div 1,500 \times 1,000 = 1.246$ ohms per 1,000 ft., which is rather less than that for No. 11 wire so that No. 10 would be used to allow for possible overload.

LOSS IN WIRING

Frequently the problem arises to find the loss in power in the wire of a circuit or a winding. If the drop in voltage for a given current be known, this loss in watts will be as already stated the voltage times the current. If resistance of the wire be known, the loss will be resistance times the square of the current flowing.

In shunt-wound motor the armature resistance is 0.02 ohm and the field resistance 58 ohms, what will be the armature loss when 125 amperes are flowing and what the field loss when the line voltage is 115?

In the armature the loss will be $0.02 \times 125^2 = 312.5$ watts. In the field, the current is found by dividing the voltage by the resistance or $115 \div 58 = 1.98$ amperes. Then $58 \times 1.98^2 = 227$ watts loss.

Going back to the circuit first calculated, which is to carry 20 amperes, the wire is 1.601 ohms per 1,000 ft. and for 300 ft. it is $1.601 \times 0.3 = 0.4803$ ohms, and $0.4803 \times 20^2 = 192.12$ watts.

For the taps which carry 2 amperes the wire is No. 14 at 2.565 ohms per 1,000 ft. For 40 ft. the resistance is $2.565 \times 0.02 = 0.0513$ ohms and $0.0513 \times 2^2 = 0.2$ watt loss for each fixture.

One other calculation is frequently necessary, the loss of voltage when a given current flows through a known resistance. In this case, the current times the resistance is the voltage loss.

For the case of the dynamo armature already used, the current is 125 amperes, and the resistance 0.02 ohm, so that $125 \times 0.02 = 2.50$ volts.

And in the case of the circuits above, the actual drop for the main line is, $20 \times 0.4803 = 9.6$ volts, and for each tap the drop is $2 \times 0.0513 = 0.1026$ volt.

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Electrician and Mechanic,
Boston, Mass.

Gentlemen: I write to call your attention to an error in the directions for the construction of a wavemeter, on page 258 of the April issue. It there states: "This . . . . consists of a box containing an adjustable condenser, a detector of the improved silicon type; *a wood form containing a number of turns of copper wire.*" On page 262 it states that each form is ¾ in. thick, making 1½ in. thick when placed upon each other. But on page 259, it shows that there is only ⅝ in. between the condenser plates and the cover, so how can the two forms be contained in the box? Fig. 1 shows one form outside the box, and Fig. 2 doesn't show it at all, so I do not know whether it belongs outside or not. I should not think it would be placed outside, as that would make a very incompact instrument. (1) If the coils were supposed to be operated outside, could I not enclose them in the bottom of the box, and by rotating them there, obtain the same results? (2) On page 263, it states: "This allows the coil to be rotated." Which coil rotates No. 1 or No. 2, and in this what is meant by "rotating"?

(3) Explain fully how coils are connected and what effect they produce when rotated. Please place these answers in the May number, as it is of interest to all your subscribers, and several of my friends, including myself must cease work on the instrument until this is cleared up. WILLARD ELDRIDGE.

Ans. (1) If you would read the article on wavemeters with care you would find that there are two coils, one having ten turns of wire and the other having twenty. Only one coil is used at a time. The coils are placed on the *outside* of the condenser case, as shown in the photographs and as provided for in the drawings. Table No. 1, giving the various values of the wave lengths on the scale divisions for the fixed condenser units shows two values: one for the coil of ten turns and under it the values when the coil of twenty turns is substituted. (2) For the reason that the proximity of the coil would alter the capacity of the condenser it *would not* be practicable to place the coil in the condenser case. As the set is constructed, the coil may be turned back over the condenser case when not in use, making the set suitable for transportation. (3) By rotating the coil, it is meant to turn the coil so that the plane of the coil rotates through the given angles. The point where the coil is pivoted to the supporting arm would be considered the axis extending through the coil, and around which it rotates. (4) In order to secure a stronger or weaker signal in the telephone receivers, the coils are built so that by rotating them with respect to the plane of the exciting circuit being measured, the coil will cut a greater or less number of lines of force, according to its position being parallel or perpendicular to the circuit mentioned.

Electrician and Mechanic,
Boston, Mass.

Gentlemen: I noticed in your various answers to correspondents and elsewhere in your magazine you recommend the use of enameled wire for induction coils. In this connection, I would like to know whether any of your staff have had any personal experience with large induction coils built of enameled wire, and whether you know of any instances where coils built with this wire have given as much as a 6 in. spark without the expenditure of much more energy than would have been required had the coil been built of a silk-covered wire secondary. I have had no experience with the use of this wire in a transformer used with alternating current, and it may be that when used for the secondary of a transformer, the rate of change being comparatively slow, the enameled wire will give a good output. In the case of an induction coil, however, where the length of spark depends altogether upon the rapidity with which the break is made, it has been my experience that the enameled wire has a large capacity, which tends to prevent any sudden change, and for this reason cuts down the output to a small fraction of what it should produce. I am acquainted with Mr. W. C. Getz, and in June, 1909, wrote him in regard to this enameled wire proposition, but do not remember that I heard from him in answer, as at that time he was just about moving from Baltimore. I give below copy of the portion of my letter to Mr. Getz, written at that time, which will give you all the data:

"I noticed your article on transformers in the *Electrician and Mechanic*, and what you state about enameled wire. Now, I would like to know whether you have ever made a good sized induction coil with enameled wire? I have. I made a coil, 2½ in. core, 18 in. long, two layers of No. 12 d.c.c. in primary, and 35 lbs. No. 24 enameled wire in 62 sections in secondary. Using 32 volts in storage battery, and about 12 to 15 amperes, I could only get about ½ in. spark. I know the sections were not bucking each other. This did not please me, and I thought possibly my secondary wire was too heavy for my battery power, cutting down the spark, and to get more voltage I got 10 lbs. more of No. 30 enameled, and wound that in 20 sections more, which I added to the other. The increased length of spark was not ¼ in., and for wireless work the coil did not seem any better than before. Using it with battery as above I could not get it to charge over 6 plates 10 x 12 with 7 x 9 in. tin-foil on each side. Then—I was talking to a friend, and he noticed the small amount of spark, and he mentioned it to a friend of his who is an armature winder or something of that sort for the General Electric. This General Electric man when he heard the coil was wound with enameled wire said that that explained it, and stated that enameled wire was no good for induction coils of any size on account of the enameled covering acting as a sort of a condenser and bucking up against the current, or rather on account of its tendency to hinder or prevent a quick change in the current flowing.

"Now, as soon as I heard this I saw a great light, and I made up my mind I had to have a good coil, so I got 20 lbs. No. 28 s.s.c. wire, and I had about 6 lbs. No. 30 d.c.c. wire. This wire I wound up into 62 sections, which gave me 39,500 turns by actual count. On the old coil with the No. 24 wire alone there were about 20,000 turns, and when I added the No. 30 the turns in all amounted to about 40,000. With this new coil, using the same battery, 32 volts, and the same primary coil, I got a 4 in. spark with interrupter working slowly so as to give the core time to magnetize. I get a regular flame 2 in. long with the interrupter working as for use for wireless sending. I can charge instead of six plates 10 x 12 as above, 25 plates, discharging across a ⅛ in. spark gap with points about ¼ in. to 5/16 in. in diameter.

"From the above you will note that my experience of enameled wire is not such as to make me recommend it for induction coil work. It may be all right for alternating or transformer work, where the change in current rate is comparatively slow, but until I get a little more information I certainly would not advise any one to use it for building an induction coil. As undoubtedly a large number of people will be building induction coils with enameled wire for the secondary, and probably will come up against my same proposition, I wish to give you my experience so you can use it for what you think it is worth in case you have not been through the induction coil end of it. My own personal opinion is that the enameled secondary will be all right for a transformer, and I have it just as I took it from the coil, and can show it to you any time. Please let me hear from you as to what you think about this matter."

I should be pleased to hear from you either by letter or through your magazine as to your opinion in the above matter, and if there are any points on which you would like to have more information, I will be pleased to let you have same if you will advise me.

Yours very truly,

WALRAM S. BROWNE,

1565 East 12th Street, Brooklyn, N.Y.

Ans. Your experiment is of exceeding interest to us, and we would like to hear from others regarding this strange condition observed. Mr. Getz informs us that while the specific inductive capacity is about 18 per cent. greater for enameled insulation than for cotton-insulated wire (authority eng. dept. Belden Mfg. Co., Chicago), he has obtained good results on a number of coils of smaller sizes wound with enameled-insulated wire, and cannot account for this discrepancy.

Mr. Curtis, of Houghton & Curtis, advises us that he has obtained most excellent results with enameled wire in the construction of several large induction coils and that the spark length and quality is considerably greater for a given amount of energy expended than when cotton or silk-covered wire is used. In an X-ray coil which has given good service, Mr. Curtis states that he used 7¾ lbs. No. 34 enameled wire of the Roebling brand, wound in 36 sections, each ⅛ in. thick. These were wound carefully and a layer or strip of cotton paper was inserted in four places in each section to afford elasticity for expansion and contraction of the wire. The core of the coil is 1¼ x 12 in., and the primary 2 layers No. 12 d.c.c. wire. With a 10-volt, 80-ampere hour storage battery and mercury interrupter, making approximately 100 breaks per second, the coil gives a fat 7 in. spark and is a powerful producer of X-rays in a Queen tube. With electrolytic interrupter drawing 11 amperes on 110 volt d.c. circuit the coil gives heavy 4 in. flame. It is, however, absolutely useless for condenser charging, and in this feature it seems to agree with Mr. Browne's experience. In the present case, however, the comparatively fine wire may partly account for this feature.

Mr. Curtis further states that the coil mentioned is only one of several in which the same results were shown. The secondary mentioned gives but indifferent results when used on the primary of an open core transformer on alternating current. On the other hand, secondaries wound with enameled wire on closed core transformers have given the greatest satisfaction.

Sampson Publishing Co., Boston, Mass.

Gentlemen: An association for the purpose of advancing ideas in wireless telegraphy has been founded in Memphis, Tenn., under the name of the Tri-State Wireless Association.

We would like to get in communication with any individuals, clubs, or associations, either in Memphis, Arkansas, or Mississippi; or in any part of the United States or Canada.

We would like you to make mention in your valued magazine the purpose of our association, and with best wishes, we remain,

Yours most respectfully,

Tri-State Wireless Association,

Per C. Cowan, *Sec'y.*

QUESTIONS AND ANSWERS

Questions on electrical and mechanical subjects of general interest will be answered, as far as possible, in this department, free of charge. The writer must give his name and address, and the answer will be published under his initials and town; but, if he so requests, anything which may identify him will be withheld. **Questions must be written only on one side of the sheet, on a sheet of paper separate from all other contents of the letter, and only three questions may be sent at one time.** No attention will be given to questions which do not follow these rules.

Owing to the large number of questions received, it is rarely that a reply can be given in the first issue after receipt. Questions for which a speedy reply is desired will be answered by mail if fifty cents is enclosed. This amount is not to be considered as payment for reply, but is simply to cover clerical expenses, postage, and cost of letter writing. As the time required to get a question satisfactorily answered varies, we cannot guarantee to answer within a definite time.

If a question entails an inordinate amount of research or calculation, a special charge of one dollar or more will be made, depending on the amount of labor required. Readers will, in every case, be notified if such a charge must be made, and the work will not be done unless desired and paid for.

1663. **Power.** W. M. H., New York City, asks what horse-power would be required to drive a 35-light dynamo, a 12 in. lathe, and a small bench metal planer? Also, what should be the cylinder and port dimensions for such an engine, and what steam pressure? Ans.—For the lights you will need about 2 kw., or 3 mechanical h.p. 1 h.p. should be sufficient for the two tools. Allowing for losses in friction of bearings and belting, you should count on having an engine of about 5 h.p. Dimensions of cylinder can be 4½ x 6 in., say, for a speed of between 250 and 300 revolutions per minute. If you prefer a higher speed, contents of cylinder should be proportionally reduced. You can figure usually on boiler being kept at 80 lbs. pressure, and engine running non-condensing. We would advise you to use piston valves, not the flat slide sort. This latter is now mostly limited to the very cheapest engines, or those that are used infrequently. Piston valves are quite as easy to make, run with less friction and respond to the action of the governor much more readily. You will find it useful to secure a copy of the General Electric Company's Bulletin, No. 4399, describing their small direct-coupled engine sets. They are largely used on shipboard.

1664. **Shocks.** W. F. C., Fall River, Mass., asks: (1) Will a person get a shock from an induction coil if he has hold merely with one hand, and then brings the other within sparking distance of the other terminal? Would same be true for static electrical machines? (2) How can figures produced in iron filings on a sheet of paper when over the poles of a magnet be transferred to blue-print copies? (3) When speaking of alternating current matters, what is meant by "sine" and "peaked" waves? Ans.—(1) Yes, you most assuredly would. Ask some chauffeur about it. (2) By placing a good plate glass mirror at an angle of 45 degrees over the filings, you can aim a camera in the ordinary horizontal direction, and get the image on the sensitized plate. Or, by putting the filings on the floor, in an open doorway, you could attach the camera to the edge of a table so as to direct it downwards to the object. Blue-prints could be copied from this negative. (3) A sine curve is the simplest and most regular of the wave forms. You will find illustrations regarding it in any trigonometry or text-book on physics. In the design of alternating current apparatus, a sine form of the wave of electromotive force is aimed at, and in low voltage machines, can closely be attained. For higher voltages, the less distributed armature windings prevent this desideratum, and peaked or double-humped waves result. Practically, the accuracy of the meters, the operation of synchronous motors, and the general regulation on the system suffers from the existence of bad wave forms. You will find some mention of the subject in Chapter XIII of the Engineering Series, in the July, 1907, magazine.

1665. **Transformer.** K. McN., Naples, N.Y., asks: (1) What should be the dimensions and winding of a 250-watt transformer for changing 110 volts to 30 volts, frequency being 60 cycles? (2) Would a 75-watt direct current motor operate satisfactorily as an induction motor at 30 volts, alternating, if the commutator should be short-circuited? Ans.—(1) The core type would probably be somewhat easier for you to make than the shell (see Chapter XVII, in the Engineering Series, in the November, 1907, number of this magazine). For the magnetic circuit the material known as "blue steel" is as good as you can get. No. 28 gauge, .014 in. thick, or even thinner will be suitable. Cut about 60 sheets to each of the following sizes: 6 x 7 in., 5¼ x 6 in., 1¾ x 6 in., and 1¾ x 2½ in. From the largest size cut out pieces 2½ x 5¼ in., so as to leave the remainder in the shape of a square-cornered U, 1¾ in. wide in every part; from the next size, cut pieces 2½ x 3½ in., also making identical U's, only shorter than the others. In doing this work the two lengthwise cuts can be made with straight shears, the crosswise one being easily accomplished against the sharp jaw of a vise with a cold chisel. Assemble these U-shaped pieces with alternating sizes, using tissue paper or asphaltum varnish for separation. Clamp and bind them with a single complete layer of hemp twine, leaving the unequally long ends of the sheets alone unbound. Use no bolts or rivets. Put on about 1/16 in. in thickness of tough paper over the string, and wind two layers, 30 turns per layer, of No. 16 d.c.c. wire on each limb. The connection between the two coils takes an S-shaped course. This winding will be the secondary; its terminals can finally be led to binding posts, and if the connection just mentioned be tapped to a third binding post, it will give opportunity for 15 volts. Put on at least 1/16 in. more of insulation and wind four layers, 50 turns per layer, of No. 16 d.c.c. wire on each limb. This will be the primary winding, its two coils being also joined together by an S-shaped connection. A binding post attached to this point will allow 55 volts to be secured. The small pieces of iron mentioned are to fill in between the protruding ends of the iron core, alternate long and short, fitting in an obvious manner. Finally these ends should be well clamped together, external bolts being quite allowable. (2) If the iron of the field magnet is laminated and the field winding not too fine, the motor will run with armature in series, *i.e.*, as a series motor; also, if you put a short-circuit connection from one brush to the other, and send alternating current through field only, armature will run as a repulsion motor. Connected as you propose, it will run, though not be self-starting, and will try to attain a speed of 3,600 revolutions per minute, *i.e.*, "synchronous" speed.

1666. **Alternating-current Motor.** H.V.G., Randall, Ark., has such a machine, rated at 1/30 h.p., adapted for 110 volts at 125 cycles. He asks if this can be rewound for use on a 60-cycle circuit of same voltage. Ans.—The change is not altogether practical, but the attempt will be educational and is worth trying. The 125-cycle motor has eight field poles, while for the lower frequency there should be only four. As you cannot change the iron itself, you can get the effect of four poles, though with distorted conditions, by winding four coils of such a shape as to embrace a pair of the polar projections; thus each coil would be somewhat over twice as long circumferentially as the present ones. They should be curved to allow for economical placing. Use wire two gauge numbers smaller than the present, and replace the "shading" coils that make the motor self-starting.

1667. **Burglar Alarm.** C. E. H., Chicago, Ill., is proposing to install such a system, using two cells of gravity battery to operate it. He asks: (1) What resistance should be connected across battery terminals, when system is out of use, to keep cells in good condition? (2) How often will materials need replenishing? (3) How can solution be kept from freezing? Ans.—(1) Put a 100 or 110 volt 16 c.p. incandescent lamp across battery terminals; to hold it a wall receptacle will be found convenient. If the blue line in the cells still gets too high, substitute a 50-volt lamp, or put two of the former size in parallel. (2) This will depend upon what current your apparatus ordinarily requires. A plentiful supply of the "blue-stone" crystals must be kept in the jars, else the blue line will get too low; if blue gets too high, temporarily reduce the resistance of external circuit, or even short-circuit the cells until the demarkation is again midway between zinc and copper. (3) You should put cells in a sufficiently warm place, say, in a cellar, or beside a warm chimney, where solution will not freeze. To prevent evaporation of the water, or the "creeping" of the sulphate of zinc, a layer of paraffin oil, say 1/8 to 1/4 in. deep, is a good remedy.

1668. **Ignition.** D. H., Oakland, Cal., has a 12-volt "Hendricks" dynamo that is used to ignite charges in a marine gasoline engine, on the "make and break" plan. He asks what changes should be necessary to convert apparatus into the "jump-spark" type. Ans.—Displace the present singly-wound "kicking" coil with a suitable induction coil, costing, say $5.00. Reduce speed of dynamo so as to give 6 to 8 volts rather than 12. The "make and break" device is displaced with a spark plug.

1669. **Induction Coil.** A. K., Colorado Springs, Col., asks: (1) What is the difference between an induction coil and an open circuit transformer? (2) What will be the output of an induction coil when used on a 110-volt 60-cycle circuit, when core is 1 1/8 in. in diameter, wound with two layers of No. 14 and 6 lbs. of No. 32 wire? Ans.—(1) Distinction between these names comes only by agreement as to usage. What are now commercially designated as "transformers," have variously been called "induction coils," "converters," and "secondary generators." Now a transformer means a device for changing alternating current to alternating current; there need not be a change of voltage, for some installations involve transformers with 1:1 ratio. An induction coil is a device that receives a rapidly interrupted direct current, and yields alternating currents at two unequal electromotive forces. A converter is a device, involving a revolving member, which changes direct to alternating, or *vice versa*, with symmetrical electromotive forces. (2) To use an induction coil on alternating current mains is usually dangerous to the coil, by virtue of the large current that passes, also it is disappointing in its output, for the reason that the change of magnetism is not sufficiently sudden. To try it, use an alternating current arc lamp reactive coil in series.

1670. **Open-Core Transformer.** C. C. F., Mansfield, Mass., asks: (1) What is the outside diameter of sections for 1/4 kw. open-core transformer, described by Mr. Curtis in the August, 1911, issue? (2) How many pounds of No. 30 s.c.c. wire could he use in place of the No. 34? (3) What is weight of primary wire? Ans.—(1) Outside diameter of sections should not be greater than three times diameter of core, say, 4 1/2 in. or at most 5 in. The number will depend upon your skill as a winder. Make secondary as short as possible with given weight of wire. (2) Use same weight of No. 30, *i.e.*, 6 lbs. (3) The primary will require 3 1/2 lbs. No. 14 wire.

1671. **Cutting Variable Condenser Plates.** E. J. W., Roxbury, Mass., asks: (1) How to cut 1/16 in. aluminum sheet for condenser plates without bending or disfiguring. (2) For the address of a firm making a specialty of rewinding telephone receivers to high resistance. (3) For sizes of wire to use on loose coupler. Ans.—(1) Sheet aluminum may be readily cut by means of a fretsaw, using kerosene oil as a lubricant. (2) We would suggest that you write to Houghton & Curtis, Waltham, Mass. (3) Use No. 24 for primary and No. 30 for secondary.

TRADE NOTES

We take pleasure in acknowledging receipt of an illustrated catalog of wireless receiving and transmitting apparatus from the Alden Wireless Co., Campello, Mass. The catalog shows an attractive line of instruments at moderate prices.

The attention of readers is called to "Oxalbitol," an antiseptic dressing which should prove invaluable to those who frequently receive cuts and other wounds during the course of their work. The modern theory and practice in the healing of wounds and curing of skin diseases, is the treating of the part in such a manner as to combat the unhealthy condition and permit nature to build up healthy tissue faster than the poisonous germs can break it down. The correction of the unhealthy condition is known as antiseptic treatment, and "Oxalbitol" is an antiseptic dressing which has the properties necessary to obtain this result.

"Oxalbitol" is composed of ingredients of known strong antiseptic qualities and is compounded under scientific methods, which give it the germ-destroying properties required to assist nature in building up healthy tissue, thereby bringing about the healing process which is the aim of an antiseptic dressing, and is the desired result in the treatment of cuts or wounds of any sort. The same treatment is effective in all skin diseases, perfecting a cure through its antiseptic action of combatting unhealthy conditions and permitting healthy tissue to overcome and stamp out the disease.

The Smith & Hemenway Co., of New York City, extend an invitation to our readers to send for literature describing their most extensive line of electricians' and mechanics' tools. Their stock comprises the complete line of "Red Devil" tools, as well as many other well-known brands.

Among the numerous specialties offered by this firm may be mentioned the Fifield "Red Devil" Drilling Attachment, which should prove a boon to metal workers. This device is essentially a portable drill press, absolutely automatic in its action of feed. With this attachment, it is possible to drill a hole in any metal, in any position, with perfect ease. No pressure is necessary as the automatic feed draws the drill steadily forward with a positive, even and continuous feed and does not allow the drill to lose its cut in the metal, a fault so often found in inferior automatic feed drilling attachments. The attachment takes any size of drill from 3/16 in. up, with ½ in. shank and bit stock drills with universal chuck.

BOOK REVIEWS

Lamps and Shades in Metal and Art Glass. Eighteen complete designs with working-drawings and full directions for their making. By John D. Adams. Chicago, Popular Mechanics Company, 1911. Price, 50 cents.

This book is similar in nature to the previous book in the same series by the same author, on "Arts and Crafts Lamps;" and gives a new selection of designs in which particular attention has been given to the construction of the shades by various methods. Metal and glass are the materials employed, but simple methods are prescribed, requiring not much skill in workmanship or the manipulation of tools, so that the work described in the book is within the power of every handyman.

The Bungalow Boys. By Dexter J. Forrester. New York, Hurst & Co., 1911. Price, 50 cents.

This is the first of a new series of books for boys, depicting the adventures of some of the students of Audubon Academy in the wilder parts of Maine. It will undoubtedly interest many red-blooded boys for its pictures of wood life and hunting and fishing scenes, as well as for its adventures in the search for a lead vein.

Elementary Principles of Industrial Drawing. By George Jepson. Roslindale, Mass., Geo. Jepson, 1909. Price, $1.00.

The aim of the author has been to present the subject of Industrial Drawing in a simple and concise form, so that the student, after he has become familiar with the contents of the book, will have mastered all the essential principles as applied to mechanical and architectural drawings. It should prove particularly useful to those students who have not had the time or opportunity to take an extended course. All superfluous matter has been excluded from the text which is well illustrated with nicely executed drawings. The examples are clearly expressed, and, taking it altogether, the little book amply fulfils its purpose.

Cams and the Principles of Their Construction. By Geo. Jepson. Roslindale, Mass., Geo. Jepson, 1905. Price, $1.50.

One of the most important parts of nearly all special machinery are the cams which impart to certain portions of a machine a regular or irregular motion regularly. Mr. Jepson has produced a little treatise on the forms, planning and drafting of cams which forms a good introduction to this somewhat specialized but highly important branch of mechanism. The book is splendidly illustrated in two colors, and the drawings are excellent specimens of draftsmanship.

A wireless telegraph station has been established by the Government of Canada at Port Arthur, Thunder Bay, Lake Superior.

The station has a normal range of 300 miles, and is available for communication with all vessels fitted with Marconi apparatus. In communicating with this station the 600-meter wave length should be used. The call letters are "MUG."

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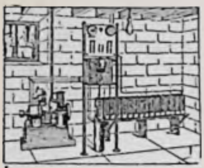

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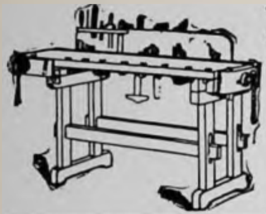

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