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ELECTRICAL ENGINEERING—Chapter XIII

Principles of Alternating Currents

A. E. WATSON

The natural condition of currents generated in dynamos is alternating in direction. A common illustration of this principle is supplied by a telephone magneto. One end of the armature winding is attached directly to the iron core, while the other end terminates in an insulated pin, resting upon a contact spring. In the absence, therefore, of any special device to rectify or "commutate" the currents, they pass into the external circuit in the very directions in which they are generated. An ordinary induction coil, too, supplies alternating currents from its secondary, but since the "break" of the primary circuit is much more sudden than the "make," the electromotive forces induced in the two directions are not equal; that produced by the break is ordinarily much the greater.

Machines of more pretentious dimensions than "magnetos" would ordinarily have both terminals of the armature winding insulated, and brought out to two rings, on which fixed brushes may rest, and serve to continue the path to the exterior circuit. Figure 49 represents this idea in most elementary form. In this a single coil of wire, presumably wound on a Siemens H, or shuttle, core, rotates between the poles of a horse-shoe magnet. The functions of the rings and brushes are also clearly seen. Probably no one is now living who entertains the old notion that the friction of brushes produces any electricity. Of course they merely provide continuity to the circuit. Since these rings have no commutation properties as have the separate segments of a commutator, they are usually denoted as collector-rings, or for short, collectors.

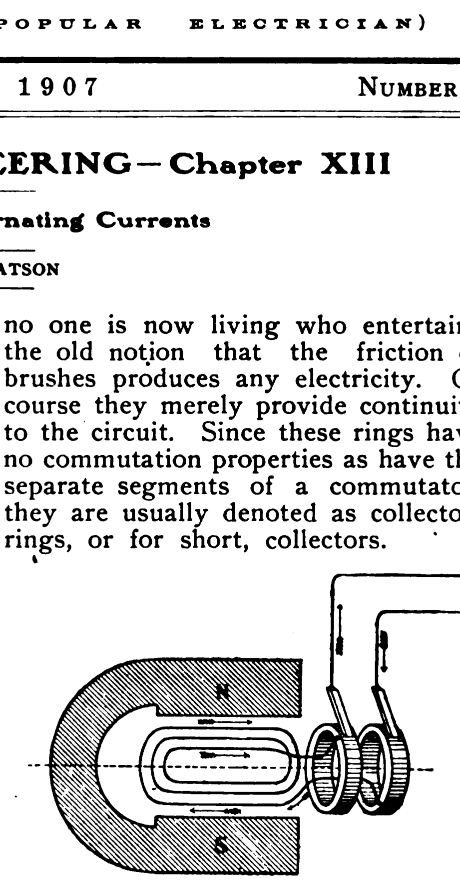


Fig. 49
Simple Alternate—Current Generator (single phase)

It is not important that the coil should do the moving; for this wire can be stationary, with the line attached to convenient binding posts, and the magnet be the revolving member. In case the latter be an electromagnet, rather than one of the permanent order as shown in the cut, its coils would need to terminate in rings through which the direct current for excitation could be led. Indeed, revolving field-magnets of multipolar design possess some qualifications not found in the other construction, and may now be said to be the standard form. In the figure, in as far as the coil is concerned, the arrows point correctly; the upper part of the winding is supposed to be moving towards the observer, and an application of Fleming's right hand rule, will give the directions as shown. Always will the principle hold, that those conductors under the north pole will experience induction in one direction, and those under the south pole in the opposite direction. At the instant taken, the current will pass on to the line, and return from the line in the indicated direction, but half a period later, when the bottom wires have reached the top position, they, in turn, will have current induced in the direction to the right, and since that terminal is connected to the other ring, the arrows in the external circuit would need be reversed.

More detailed descriptions of the actual construction of the generators will be given in a subsequent chapter, but it is appropriate at this point to suggest that only the serious reader will be able to conceive and arrange the various factors concerned in a treatment of the properties and performances of alternating currents. Simple arithmetical methods of computation are insufficient, and ordinary expressions fail to convey the whole idea. A new language must be learned, unexpected factors admitted and analyzed, algebraic or geometric processes adopted, and graphical representations devised. Definiteness is further hampered by the knowledge that not one of the fundamental qualities has visible existence, and though treated by slow logic, they in reality may move with frightful rapidity. A complete theory of alternating current phenomena is replete with most extended mathematical processes and physical conceptions but this article will be limited to the barest suggestions compatible with accuracy.

When a given coil of an armature winding is midway between the poles of a field magnet, no lines of force are being cut, or in other words, there is no **change** in the number of lines of force threading through the coil, and therefore no electromotive force is being induced; as the coil approaches one pole, change does take place, and under the centre of a pole, the change is most rapid; then when the coil has made half a turn, induction again ceases; during the second half of a revolution, the coil is under the influence of the other pole, and experiences an induction just equal to the former, but in the opposite direction. It is certain that one direction of the electromotive force is just as useful as the other. How can such a change of values be represented, both graphically and numerically? The performance of a simple coil rotating in an elementary

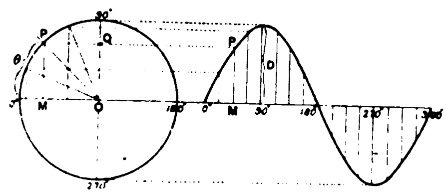


FIG. 50

Curve Representing Alternating Current or Electromotive Force

two-pole field can be analyzed into four stages, constituting a complete "cycle," i. e. the rise of the electromotive force from its zero to its full value, under one pole, its decadence to zero again, its rise to an equal maximum value in the other direction, and its return to the original zero condition. Further revolutions would be mere repetitions of this cycle. In a two-pole field magnet the number of cycles in a second is equal to the number of revolutions per second; in a multipolar field magnet, the same cycle of changes would be produced in part of a revolution, i. e. in the time required for a given coil to pass from one pole to the next one of the same kind.

The trigonometric curve of "sines" shown in Fig. 50 is at once available for depicting these changes. A circle of any convenient diameter may be drawn, and the circumference divided into equal parts, the principal divisions of course being 0, 90, 180 and 270 degrees. Likewise a straight line through the centre, of any convenient length, may be divided into 360 parts, and vertical lines drawn through as many points as were in the circle. By projecting successive points in the latter upon the corresponding vertical lines, intersections will be formed, and a curve through them will be in the shape represented. That portion of the curve above the axis is called the positive branch, and that below, the negative branch. In actual machines, the real instantaneous values of the electromotive force do not form such a uniform path as that shown, but the aim is so to shape the coils and pole pieces as to approach it as near as consistent with good mechanical construction.

The effective value of an alternating electromotive force or current evidently cannot be represented by the maximum vertical line, or ordinate, of the curve, for that value is held but for an instant; neither can the zero value be taken for that is an even shorter instant, and there is plain proof that the alternating current really exists. A mean must be taken somewhere between the zero and the maximum, with extra weight given to the latter in consequence of its longer prevalence. A principle in physics gives the clue; this states that the energy of a wave motion is proportional to the square of the amplitude. The straight line, 0 to 360 degrees can be conceived as extended to a length of several feet, and the sine curve produced by the vibrations of a musical chord, with a node in the centre. Each part of the string would have its own amplitude, and the energy of the vibration would be the square root of the mean of all these squares. To find it simply, one has only to consider what is the mean, or average square between the extremes,—zero-square and the maximum or one-square. Plainly it is one-half-square, and an area of half a unit square, or .5 has one side of that square .707 in value, for .707 square equals .5. From another point of view, half way between 0 and 90 degrees is 45 degrees; the sine of 0 degrees is 0, and the sine of 90 degrees is 1; but the sine of 45 degrees is .707. The calculus also serves as a means of deriving this value, but the suggestions already given will suffice. The conclusion is that an alternating electromotive force or current has an effective value of .707 of the maximum; that is, if an alternating electromotive force was periodically varying between 0 and 100 volts, it would produce the same deflection on an appropriate voltmeter, as 70.7 volts with direct current. Or, if 1000 volts alternating is being generated in a dynamo as indicated by the voltmeter, the potential really has a momentary maximum value of 1000 divided by .707 equals 1414 volts. Insulation tests with alternating currents are therefore much more rigorous than with the same nominal value of direct current pressure. Not only does the maximum exceed that of the latter, but being exerted first in one direction, then in the other, greater disruptive stress is exerted.

In the case of direct currents, the power in watts is found by simply multiplying together the number of volts and amperes. In some kinds of circuits this is a true method also, with alternating currents; in other kinds it is not even approximate, and in extreme cases, quite misleading. These two kinds of circuits are technically designated as "non-inductive" and "inductive," the former being typified by an incandescent lamp or other heat load, and the latter by an aggregation of iron and copper as might be found in an electric motor. Whenever an electric current changes in strength, it changes the amount of magnetism contained within that circuit. Magnetism is conveniently estimated in lines of force, and there is a law of Faraday's as inexorable as that of gravitation, that whenever the number of lines of force in a circuit changes, an electromotive force is produced. It is important to recognize in what direction this self induced electromotive force acts, and when it has its maximum and zero values. If the curve shown in Figure 50 be now regarded as showing the number of amperes in a given circuit, it will be seen that at the zero and 180 degree points, the rate of change is the greatest, for just before either of those values the current was flowing in one direction, and just afterwards, it was flowing in the opposite direction; any iron that might have been within a coil then experienced a reversal of polarity,—an extreme change. At the 90 and 270 degree points, the current momentarily became steady, and all changes in strength of magnetism plainly ceased. The maximum electromotive force of self induction was then induced at the 0 and 180 degree points of the current curve, and none whatever at the 90 and 270 degree points. If a second sine curve was drawn on top of the first, the new one, to show the instantaneous values of the self induction, its maxima would be just over or under the zero values of the current curve. In other words, it would be displaced one quarter period, or 90 degrees, from the current curve. Self induction is a factor in electrical circuits analogous to inertia in mechanics; it exerts a force in the direction always to oppose a change; the whole designation, the counter electromotive force of self induction is rather cumbersome, and the expression, "reactance voltage," is a common substitute. To overcome the reactance of a circuit of course additional voltage over that required for the ohmic resistance is needed, but the exact amount is not the arithmetical sum, for the maximum values of the two forces need to be exerted at different instants. That to overcome the ohmic resistance is directly proportional to the current, having its zero value coincident with the instant of no current, and its maximum, when the current is to be a maximum. That to overcome the reactance, as already explained, has its maximum value when the current is just at its zero value, i. e. a quarter period, or 90 degrees, different in time period, or "phase." Now a convenient way to represent 90 degrees is by a right angled triangle. If a base line be drawn, in length proportionate to the resistance of the circuit, and at one end, say the right, a perpendicular be erected, proportionate to the reactance, the hypotenuse that may be drawn will represent the geometrical sum of the two factors, and actually measure the total "impedance" to the flow of current. The acute angle at the left will represent the amount by which the current "lags" behind the electromotive force; the amount is of course an interval of time, but graphically represented by the time it takes the armature coil to pass over a given angle. If the resistance of a circuit is great as compared with its reactance, as in case of an incandescent lamp, the vertical line disappears, and the resistance and impedance become identical, and the angle of lag is zero. If the circuit is a reactive, or "kicking" coil, or the primary of a transformer, the resistance may be almost negligible, and the base line disappear, while the vertical line may closely represent the impedance; the angle of lag then approaches 90 degrees. Even if the resistance became actually zero, it is seen that the angle of lag can never exceed 90 degrees. The circuit that has both resistance and reactance is represented by intermediate lines. For an illustration take the case of a modern enclosed arc lamp, such as was shown in Figure 17 of Chapter IV., adapted for use on a circuit of 104 volts and 60 cycles, normal current being 5.5 amperes, with 72 volts difference of potential across the arc itself. The reactive coil in top of lamp is to take care of the difference between 104 and 72, but the arithmetical difference of 32 is not correct; the right angled triangle must be drawn as shown in Figure 51. The sides can as well represent volts as ohms, so both cases are given. Seventy-two divided by 5.5 equals 13.1, or the number of ohms resistance of the arc itself. In the copper windings of the reactive and regulating coils there may be a resistance of 1 ohm more; therefore, in all, the base line of the triangle will be 14.1 units long, to represent the ohmic resistance, or 77.5 units to represent the volts. Erect a perpendicular at the right hand end, and with a radius of 104 divided by 55 equals 19, and a center at the other end of line, swing an arc until the vertical is intersected; now draw a straight line connecting the two points. The corners of the triangle may now be conveniently

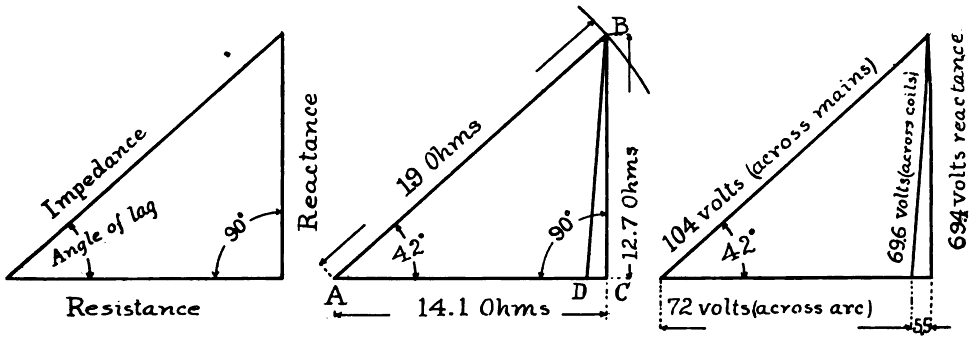


FIG. 51
Triangles Illustrating Resistance and Electromotive Force in an Alternating Current Enclosed Arc Lamp

lettered A, B and C. Measuring off BC, it is found to consist of 12.7 approximately, and multiplying this number by 5.5, the actual number of volts exerted by the reactance of the circuit is found to be 69.4, that is measured around the corner, 77.5 plus 69.4 equals 104. The angle BAC represents the amount of lag of the current in the lamp as a whole, while the angle BDC is that in the kicking coil alone,—closely 90 degrees. Those familiar with geometry will at once recognize that AB is merely the square root of the sum of AC and BC squared, and that with any two of these values given the third can readily be found. Likewise, by trigonometric principles AB divided by AC is merely the cosine of the included angle, but because that term may not be entirely suggestive to many artisans, the equivalent expression "power-factor" has been substituted. Its numerical value is always less than unity.

This long digression has been merely for the purpose of providing means for estimating the power in an alternating current circuit. Instead of using the maximum values of electromotive force and current, it is obviously more convenient to utilize the effective values indicated on the measuring instruments. By the aid of the power-factor the component of the mean or effective current that is in existence when the volts are at their mean value can readily be found. Hence by multiplying the number of volts by the number of amperes and by the power-factor, the correct power in watts is obtained. If there is no lag of current, the power-factor is unity and the ordinary product of the volts and amperes results, as with direct currents. If the angle of lag is very large, the power-factor is a very small fraction, and while the instruments may indicate normal readings, the actual power utilized or developed by the dynamo may be incredibly small. With inductive circuits, **volts x amperes** and **watts** are quite two different things. In the case of the arc lamp, the volts x amperes equals 104 x 5.5 equals 572; but the power-factor equals 77.6 divided by 104 equals .746, and 572 x .746 equals 437, the true number of watts consumed.

Though logical, and with correct numerical results, this reasoning may have been a little tedious, and by its lack of material embodiment, may have failed to be as convincing as desirable. This defect is unavoidable, and if electricity itself is unknown and invisible, it is not strange that conventional and indirect methods of representation and treatment are involved. Still graphical diagrams can represent some elements of the truth, and this is conspicuously the case with the power measurements. Diagrams will be given to illustrate three typical cases,—one in which there is no lag of the current, a case corresponding to an incandescent lamp load; a second, in which the current lags by 45 degrees, closely typified by the arc lamp just explained; and a third, in which the current lags by quite the theoretical limit, 90 degrees; a close approximation in practice to the last is the instance of an ordinary transformer primary, when the secondary circuit is open. As no particular values of current and electromotive force are needed to illustrate the principle, the ones shown have maximum values of 7 amperes and 3.5 volts, respectively. Any other numerical values would have served just as well. As far as the readings of the instruments are con-

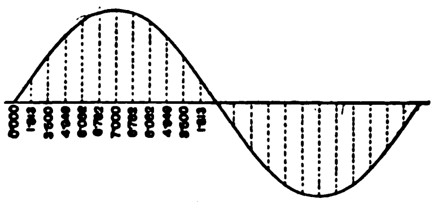


FIG. 52
Current Curves

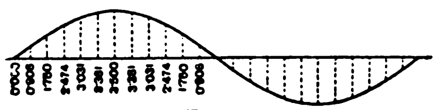


FIG. 53
E. M. F. Curve

cerned, they would show these values multiplied by .707, or about 5 amperes and 2.5 volts. These component curves are shown in Figures 52 and 53.

Figure 54 illustrates the power actually in circuit when there is no lag of the current behind the electromotive force. The zero values of both curves occur at the same instant, likewise their maximum values, and the product of these two factors gives the true instantaneous power in watts. At 0 degree, the power is zero; at 90 degrees the product of the factors

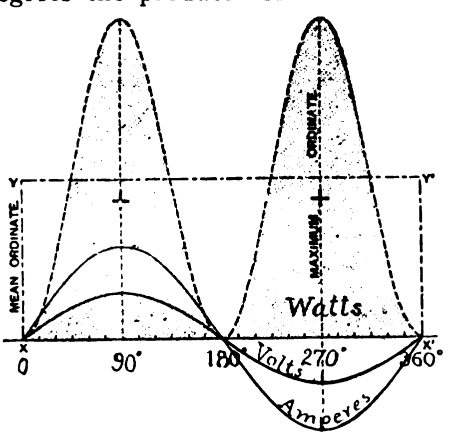


FIG. 54
Power Curves. No Lag of Current

gives 24.5, the maximum value; at 180 degrees the power is again zero, and at 270 degrees again a maximum; although in this half of the cycle, both current and electromotive force are represented below the axis, and therefore negative, all that the negative sign means is a reversed direction, and current in one direction is as good as that in the other, and fully entitled to be regarded as of positive value. Also by the algebraic principle, that the product of two positive quantities is positive in sign, so the product of negative factors, too, gives the positive sign. The power in circuit is alternately 0 and 24.5 watts, and a wattmeter would indicate .707 of the maximum or 17.32 watts. A rectangle is shown in dot-and-dash lines having a base XX' and height YY' of 17.32 units, embracing an area equal to that of the two shaded sine curves, meaning that a steady, or direct, current under such pressure as to represent 17.32 watts would do the identical work.

In Fig. 55 the zero value of the electromotive force was at a certain instant, but since that instant, the

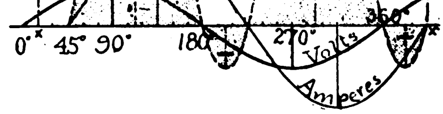


FIG. 55
Power Curves. Current Lagging 45°

armature coil has had to turn through an angle of 45 degrees, before the current was driven to its zero value; similarly the voltage wave reached its maximum and began to decrease in value before the current had attained its maximum, in the same direction. The zero values of the two curves do not therefore coincide, and since the product of the ordinates gives the instantaneous power, and with the algebraic principle that if either factor becomes zero, the product also becomes zero, there will now be four such instants, and at other times there will be products that result from the multiplication of factors with unlike signs. Thus at 45 degrees, the electromotive force is something, but the current is zero, therefore their product is zero; the power curve then begins at that point. Until the 180 degree point is reached, the e. m. f. and current waves are real and positive, so their product gives a positive area, with a maximum at 112.5 degrees. At 180 degrees the e. m. f. becomes zero, and so, too, the power. Between this point and 225 degrees the current, however, remains positive, while the e. m. f. has become negative, hence their product, though real, is also negative. This is represented by an appropriate shaded area below the axis. Between 225 degrees and 360 degrees both factors are negative, therefore their product is positive and again drawn above the axis, while between 360 degrees and 405 degrees the e. m. f. is again positive, while the current remains negative, and the product is a second negative area. The real power expended in the circuit is the difference between these positive and negative areas. It is seen that the maximum value of the power is less than in the case shown in Figure 53, and when the subtraction of the negative areas is made the equivalent rectangle actually sinks to the dimensions of XX'YY',—the height being only 12.125 units.

By the expression that the electromotive force is positive while the current is negative, is merely meant that though the former has actually changed its direction, it has not yet succeeded in reversing the flow of the current. The case of trying to reverse the direction of rotation of a fly wheel is analogous; though force may be exerted, the contrary motion may continue for an appreciable time. The example of the lag of a result behind its cause is one not unknown in other lines of nature, notably in the conduction of heat. The coldest season in winter is by no means coincident with the shortest days, but lags by some two months; also, while the sun is above the horizon longest in June, the most sultry days do not accur until August. Neither is twelve o'clock the hottest instant of the day, but that lags until about two o'clock, while the coldest part of the night awaits until nearly sunrise.

Figure 56 shows the third, and is a very interesting case; it is almost self explanatory. There are the four zero values of the power per cycle, but the positive and negative areas are equal. Although ammeter and voltmeter may still indicate full values, a wattmeter

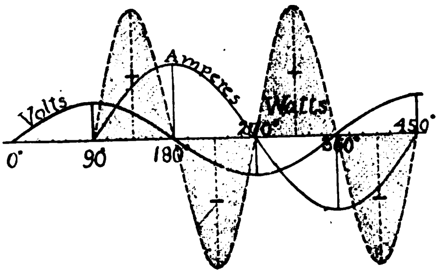


Fig. 56
Power Curves. Current Lagging 90°

would show zero, and no power would be required to drive the dynamo. It is true that at one instant, the dynamo does supply power, but at the next it receives it back again from the particular piece of apparatus in which this 90 degrees lag is produced. It is the case of a pendulum swinging to and fro; force is exerted in falling to its lowest position, but all is needed to drive it to its other extreme position, where for an instant the energy is all potential, being stored in the stationary weight, then when moving most rapidly in its lowest position, its energy is that of motion, i. e. in the kinetic form; the intervals between these two positions are one-quarter of a complete period, or 90 degrees. So with the electric current, at one instant, there is the maximum potential energy in volts, but no current; one-quarter period later, there is the moving current, but no voltage. No work can be done by the swinging pendulum, indeed, it requires the additional force of the spring or weight to keep it moving against its fractional resistances. So the current that lags by one-quarter period carries no useful energy, but demands just enough voltage to overcome the meagre ohmic resistance of the circuit.

With this introduction to some of the peculiarities of alternating currents, considerable progress may be made by the reader in an understanding and appreciation of the practical working of a large variety of apparatus. Further theory, with simple means of expressing numerical relations will be reserved until the actual application actually arises. The fourteenth chapter will treat of alternating current generators.

The Amateur's Workshop

An Experimental Wireless Telegraph Outfit

T. E. O'DONNELL

The wireless telegraph apparatus as employed by Marconi, DeForest and others, is quite complicated and expensive, but for experimental purposes the amateur can arrange a simple set of apparatus that will give good results. The apparatus required is very largely a combination of the more simple electrical devices.

The different parts that go to make up a wireless telegraph outfit are: The Induction or Ruhmkorff Coil; Condenser; Transmitter; Receiver; Coherer; Decoherer; Relay, Sounder; Aerial, Ground, and Local Line Batteries; Aerial and Ground Wires and Plates, in which order they will be taken up and discussed.

INDUCTION COIL AND CONDENSER

Since the construction of the induction coil and condenser was treated in the April and May, 1906, issues of this paper they will not be repeated in this series of articles. The instruments treated there are identical with those required for this work, as the coil will give good results for short distances. Any good induction or Ruhmkorff coil giving a 1-4 inch or 1-2 inch spark may be used. Of course the larger the coil the greater will be the distance over which messages can be transmitted.

For work in wireless telegraphy it is necessary that the coil be fitted with oscillators. The smaller coils are not provided with these and hence the experimenter must procure them separately. These are two brass balls about 7-16 inch in diameter, attached to the coil as shown at—A—Fig. 1.

The oscillators should be well polished and always kept bright and clean, so that it is possible to get a good, snappy spark between them, when the coil is in operation. A suitable set of oscillators may be made from two brass balls of the above diameter by boring a small hole in the side of each, inserting a piece of No. 16 brass wire and then soldering it in. These are then to be mounted in the binding posts on top of the coil, and adjusted to about 1-8 inch apart. At this position a short, heavy spark will result, which it has been found emits waves of greater intensity and hence is the most efficient for this class of work.

The apparatus comprising the transmitter consists of a source of E. M. F. or battery, a key, an induction or Ruhmkorff coil, and an oscillator attachment. The source of E. M. F. or battery generally used is three or four cells of some good short circuit battery, such as the Grenet or Bunsen. A small storage battery also gives good service and is used quite extensively in large sets of apparatus. For the present work, however, ordinary dry-batteries can be used, but better

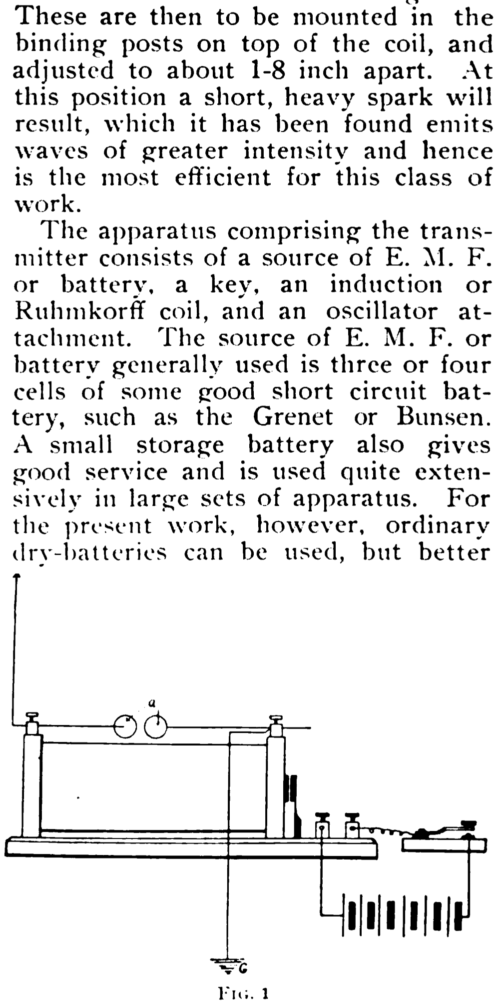


FIG. 1

results can be obtained by using the others.

THE KEY

In order to break up the current arbitrarily into dots and dashes, a telegraph key is interposed in the primary circuit; the key usually employed is constructed like the ordinary telegraph key. A very suitable key may be made from a strip of 1-16 inch spring brass, 3 inches long, 1-2 inch wide at one end, and 3-8 inch at the other. At each end is bored a 1-8 inch hole. A small wood or ebonite button is mounted on the smaller end, while the other end is screwed down on top of a wooden base 1-2 inch x 2 inches x 3 1-2 inches. The screw at this end, which holds the spring down, also serves as a binding post. The other connection is made by a round-headed brass screw set in the base just beneath the free end of the spring, which carries the button. The circuit is completed by pressing the spring down so as to make contact with the head of the screw, the operation being similar to that of the regular telegraph key. Fig. 1 shows the method of connecting up the different parts of apparatus comprising the transmitter.

THE RECEIVER

The apparatus comprising the receiver, or receiving station, consists primarily of a coherer, decoherer, telegraph sounder or electric bell, relay, battery for operating sounder, and battery for operating decoherer.

A simple receiver can be arranged by using a common telegraph relay and a sounder or even an electric bell. In the circuit of the sounder or bell, and its corresponding battery, is placed a relay, which is controlled by the coherer and the battery in circuit with it.

THE COHERER

The coherer, in its ordinary state, presents so much resistance to the battery circuit that it is not strong enough to work the relay, which operates the local circuit. But if the coherer is put in tune with the transmitter, and a spark passes between the oscillators of the induction coil, the wave thus set up will break down the resistance of the coherer which will cause the battery current to pass and operate the relay. The relay making contact, completes the circuit of the sounder and local battery.

This is due to the fact that when the waves pass through the coherer, they change the resistance of the mass of filings, which is usually very high, to a comparatively few ohms.

To make a coherer take a piece of glass tube 2 inches long, with a 3-16 inch bore, and fit into it two pieces of German silver rod each 3-16th inch long, and of such a diameter as to fit closely in the bore. Solder on one end of each a No. 20 bare copper wire. One of the pieces of silver rod with the wire attached is placed in the tube as shown at—A—Fig. 2, and the tube sealed off around the wire. A small quantity of medium coarse silver and nickel filings are then to be put into the tube at the open end.

The proportion of filings to be used is 4 per cent. silver and 96 per cent. nickel. A small drop of mercury is to be dropped into the tube with the filings. A convenient way of obtaining the filings is by filing a ten-cent piece for the silver and a five-cent piece for the nickel filings. When the filings are in place, the second German silver rod is inserted in the tube, al-

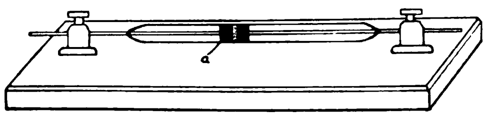


Fig. 2

lowing a space of about one millimeter between the ends of the rods. This space should be a little more than half filled with the prepared filings. When at the proper distance the tube should be sealed off around the wire in the same manner as at the other end. The coherer being completed is then mounted in two binding posts upon a wood base as shown in Fig. 2. The coherer will last longer and work better if the air is exhausted from the tube before it is sealed the last time, as this prevents the filings and mercury from being affected by oxidation.

The experimenter may be desirous

of experimenting with different forms of coherers, to see which will give the best results. A more simple form of coherer may be made from a glass tube 2 inches long, 3-32 inch in bore, by inserting in each end a short piece of brass rod that will fit the tube very closely. They should be smoothed off with emery paper until bright and clean.

This form of coherer may be mounted in the same manner as the other, the binding posts in the case being of large size and with thumbscrews, in order that the rods may be adjusted to the proper distance and held rigidly in place. Interesting experiments may be performed with this instrument by using filings of different compositions, such as: iron filings and drop of mercury; iron filings alone; mercury alone; nickel 5 per cent., iron 95 per cent.; or iron 5 per cent., aluminum 95 per cent.

Electro-Plating and Gilding

VIII. Source of Power

W. H. MOORE

SOURCE OF POWER

The electro-plating dynamo is essentially different from other electric machines, such as are used for the production of light or the transmission of power. In these the voltage is high and the amperage low as compared with the plating machine, and it is the designer's and manufacturer's aim to produce for electro-deposition a dynamo capable of a heavy current at a low voltage, without undue heating of the coils and commutator, and in consequence a generous use of copper and iron is essential in its make-up.

It is not our purpose to give working drawings and directions for making one of these machines, for an efficient one is not easily made by the amateur, but rather to point out the chief requirements and to show their capacity, and the size required for various amounts of work. If the amateur is bent on making his own dynamo, he can well consult the books on the subject offered by this magazine.

The principal points for the designer to keep in mind, aside from those mentioned, would be first, a magnetic circuit of low magnetic resistance—therefore short compact pole pieces of very soft cast iron. Second, field coils of a size and wire to give greatest efficiency with least heating effect—for whatever energy is lost in heat in a machine, whether it be from the resistance of field or armature, or from the friction of the bearings, in so much is the efficiency of the machine reduced—energy is expanded by our engine for which we get no equivalent in work from the dynamo—we sustain a loss of so many watts, and every watt used is charged to the plater who buys his power.

Third, a laminated and well-ventilated armature. The core of an armature was formerly, and is today, in small, low-priced dynamos, made of one piece. It is found much more efficient if made up of a series of punchings of soft sheet iron, called laminations.

The copper winding on the armature should be very short and heavy, for remember, it is a heavy current and low voltage we are after. In a well-designed machine, sections of the armature winding should be capable of removal in case of injury, without interference with the remaining sections.

The shafts should be of crucible steel, ground to exact size and run in self-aligning and preferably self-oiling phosphor-bronze bearings.

Fourth, the commutator, a very important, though small part comparatively of any dynamo, should be extra heavy and made up of extra dense hard-rolled copper segments, so as to stand much wear without reduction in size and therefore current carrying capacity.

Fifth, the brushes should be of best quality woven-wire type, securely held by heavy copper or brass holders and connected to heavy leads.

The machines in the table below from number 2 to 8 inclusive are compound wound. The purpose of this is to maintain a uniform voltage under a varying load. The shunt wound dynamo, running under overload, will drop in voltage. As a result the current through the shunt (i. e. the field coils) is diminished and the output of the machine is reduced.

The compound wiring consists of a few turns of heavy wire (in series with the external circuit) around the poles and forming part of the field coils. With this arrangement, under overload, the current in part of the field coil is reduced as before, but the increase in flow to the external circuit passes around the field coils at the same time, and thus the loss in the main field coil is compensated for, and a uniform voltage is the result.

In the accompanying table the values show the results from the use of standard sulphate nickel solution and standard acid copper solution. The distance between electrodes was about four inches, and sheet brass was used to receive the deposit.

Under the heading "Square feet per hour," the nickel deposited was .0004 inches thick, the copper .001 inch, while the silver was what would be considered "good plate."

The amateur who has a dynamo, should see to it that the bearings are always well oiled, that they remain cool, and that the machine is run at its rated speed. The belt should be fairly tight, so that no slip occurs, and the brushes should be frequently looked after for excessive sparking. A drop of oil on the finger applied to the commutator will often reduce the sparking. If not, the bearing surfaces of the brushes should be looked after, and possibly their position relative to the position of the pole pieces readjusted.

TABLE OF DATA FROM TESTS MADE ON VARIOUS SIZES OF PLATING DYNAMOS

Number machine	Amperes at 6 volts	H.P. at full load	Size pulley inches	Size lead wires	Speed R.P.M.	Number of Poles	Square feet per hour		
							Nickel	Copper	Silver
A	12	⅛	2x1¼	No. 10	1800	2	3	1.5	5
½	20	¼	2x1½	10	1800	2	6	3	10
1	35	½	2x2	6	1300	2	12	5	17
2	65	⅞	3x2	4	1200	4	24	9	37
3	125	1½	4x2½	0	1000	4	41	18	62
4	250	2¾	5x3	½ inch	900	4	83	35	125
5	400	4¼	6x3	⅝ "	800	4	133	57	200
6	700	7	7x4	¾ "	700	6	233	100	350
7	1000	9¾	8x5	1 "	650	6	333	143	500
8	1400	12½	10x6	1¼ "	600	8	466	200	700

The Construction of a Magnetic Detector

BY EDWARD G. GAGE

The researches of Joseph Henry brought out the fact that the discharge of a Leyden jar through a coil of wire surrounding a needle produces an effect quite unlike that of a voltaic current. Instead of being uniformly magnetized, the needle is seldom magnetized twice alike throughout its length, and its poles are often reversed.

Although Henry rightly guessed the true cause of this irregular magnetization, namely, that the discharge is oscillatory, the principle was not applied by him in detecting oscillations at a distance; but Rutherford, some fifty years later, utilized this principle in his detector of electric waves.

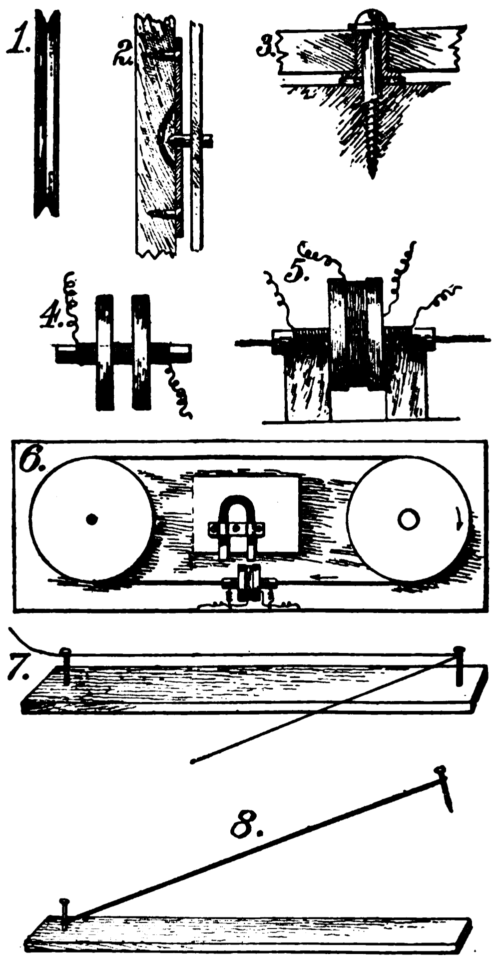
A small magnetometer was placed near one end of the needle, previously magnetized to saturation, and the changes in magnetism caused by oscillations from the distant oscillator passing through the coil surrounding the needle were noted by the deflections of the magnetometer.

This apparatus was, of course, suitable for experiments only, in that a freshly magnetized needle was required after every discharge of the oscillator.

Marconi overcame this difficulty by supplying a constant source of variable magnetism in the shape of a permanent magnet, which, being slowly revolved by clockwork with its poles facing the coil of wire, supplied fresh magnetism to the core, which instead of a needle was now a bundle of thin iron wires.* As a further improvement Marconi discarded the magnetometer for noting the passage of oscillations, and in its place wound a second coil of fine wire over the first, which picked up the induced currents, and led them to a telephone receiver in which a click could be heard for every spark discharge of the transmitter.

Even this form of detector had its drawbacks, as the signals received were constantly varying, being strongest upon the approach of the magnet poles to the core, and weaker when receding, making

*See paper by Marconi before Royal Inst. of Great Britain, June 13, 1903, in ELECTRICIAN June 27, 1903, p. 388.



it unsuitable for practical work. Again Marconi has overcome the difficulty by arranging the detector in the manner later described.

Although the operation of the magnetic detector is commonly called one of hysteresis, in which the magnetism of the core lags behind the magnetizing force of the permanent magnet, and is suddenly set free by the passage of oscillations through the primary coil surrounding it, the true operation, like that of the electrolytic detector, is disputed by several investigators.

It is sufficient, however, for practical needs to accept the hysteresis theory, and to so proportion the windings, core, magnet, etc., that they shall be best suited to a happy medium of wave lengths, telephone receivers, and signal strengths.

This has been accomplished in the modern commercial detector, which is due to Marconi, and is wonderfully constant, "fool-proof," and ranks next to the barretter or electrolytic detector in sensitiveness.†

Directions for making a home-made detector of this character are as follows:

A suitable baseboard for the instrument is first selected from straight-grained pine, 18 inches long, 6 inches wide, and ⅞ inch thick.

Procure the works from an ordinary clock, preferably of the eight-day variety, although those from an ordinary alarm clock will be chosen here for the sake of simplicity. Remove the balance wheel and all unnecessary cogs, screws, etc. To one end of the spindle of the last cog-wheel solder a narrow strip of tin 1 inch long and ⅛ inch in width, to serve as a dog to hold a wind-brake, this to cause the wheels to revolve slowly and quietly. The tin strip should have a small hole punched through the centre and placed over the end of the spindle, which projects a trifle from the under frame. A small drop of solder will secure it, after which any form of small cloth or paper vane may be attached by a wire loop or frame. Owing to the difference in construction of various clockworks, it is difficult to specify any shape or position of the brake, but the one shown in Fig. 11 gives the general idea. Cloth over a frame is preferable to paper or cardboard, as it moves silently. Allowance should be made for the movement of the vane, either by cutting away the wood around it, or projecting the vane through a hole in the base, and supporting the whole instrument on a superficial base by means of cleats. The spindle to which the hands are attached serves for the driving shaft, and should be soldered to the cog-wheel through which it passes, as ordinarily it is held by the friction of a spring pressing against it.

†The recent introduction of the compound of silicon and carbon as a detector of electric waves, and also a modified form of Fleming's rectifier used for the same purpose, renders this statement liable to error.

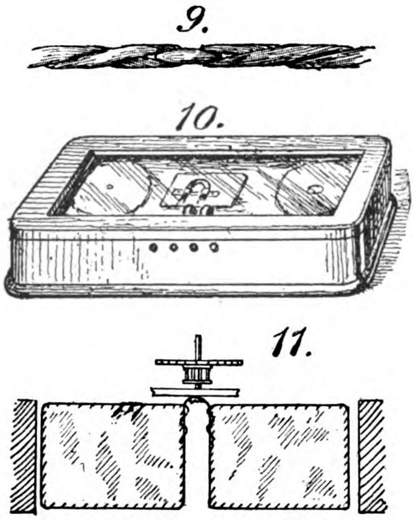
Two wooden discs, preferably birch, are now cut out, 4 inches in diameter and ⅜ inch thick. Upon the periphery of each disc is cut a groove of the shape shown in Fig. 1.

From a piece of heavy sheet brass cut a square 2 x 2 inches and drill a ⅛-inch hole in each corner and one in the centre to fit the driving spindle on the clockwork. Place in position on the spindle and fasten with solder, being careful to keep it true. Hollow out the centre of one of the wooden discs sufficiently to contain the lump of solder so formed, and fasten it to the brass square by means of small steel screws passed through the hole in each corner (Fig. 2). A small magnetic screw driver will be found very useful for passing the screws into place through the open work of the clock frame.

The clockwork is now mounted on one end of the board, the centre of the disc being 3 inches from the edge. Stove bolts passed through open parts in the frame from the bottom of the baseboard and fitted with nuts and washers will be found the best method of doing this. A hole should be bored in the baseboard immediately beneath the winding stem, to allow for the insertion of the key. Next cut a block of soft wood 5 inches square and of a thickness 1⁄16 inch less than the distance between the top of the baseboard and the under side of the mounted disc. The remaining disc is now fitted with a brass bushing and a 1-inch round-head brass screw selected to fit the hole in the bushing nicely, and passed through it into the block of wood just mentioned, placing a washer beneath the disc and one under the screw head (Fig. 3). Fasten the block to the baseboard in a position so that the distance between centres of the disc shall be 12 inches.

This finishes the framework, and the coils should now be wound and adjusted. Obtain a piece of annealed glass tubing, as thin as possible, 2 inches long and ¼ inch external diameter. Hold the ends in a Bunsen flame just long enough to smooth the rough portions, flaring one end slightly with a small stick of wood. This prevents chafing of the iron rope.

In winding the primary coil over this tube it is a good plan to tie the ends



THE CONSTRUCTION OF A MAGNETIC DETECTOR

tightly with thread, to prevent slipping. The wire used should be No. 36 silk-covered, and should measure 10 feet in length. It is wound in a single layer as closely and evenly as possible, leaving 6 inches of the wire at each end for connecting. The coil when wound should occupy a space of 1½ inches in the centre of the tube. Give the whole a good coat of shellac and allow to dry.

Over the coil and tube so formed are slipped two small discs of ¼-inch soft wood 1½ inches in diameter (Fig. 4). The hole in the centre of the discs should be just large enough to fit over the coil tightly, and shellac used to hold them in place. They should occupy a position in the centre of the tube, being set ⅜ inch apart. When they have become firmly fastened in place the space between them is wound full of No. 36 silk-covered wire, leaving free ends about a foot long for connecting (Fig. 5).

Tube and coils are now placed in position on the baseboard so that the interior of the tube is in line with the grooves on the periphery of the discs, and the coils midway between them (Fig. 6). Support the tube on a pair of blocks, as shown, using a liberal amount of shellac to hold it in place.

Cut out another wooden block 4 inches long, 2 inches wide, and of about the same height as those supporting the tube. Fix this block lengthwise in the centre of the baseboard. Procure a small permanent magnet of the horseshoe variety, and mount it on the block in such a position that its north pole will be pointing directly in front of and nearly touching the outside turns of the secondary coil (Fig. 6), while its south pole will be opposite one end of the tube. If the disc on the clockwork revolves from right to left (as it ought), the south pole should be to the left of the centre of the tube and coils; if in the opposite direction, to the right. It is immaterial which pole is in front of the secondary coil, as long as the remaining pole is in the proper relation to the direction of the moving band, about to be described. The commercial instrument is fitted with two magnets, like poles adjoining, and facing the centre of the secondary coil, but the difference in effectiveness of this arrangement is so slight as to be unnoticeable.

We now come to the last, and if not properly made, the most difficult and exasperating part of the detector, the moving band or rope of iron wire. To the uninitiated this has always been a source of great difficulty and annoyance, and though simplicity itself when made in the following manner, attempts at other methods are almost sure to result in a bungling, tangled mass of stray loops and ends.

The wire of which the band is made is No. 36 silk-covered, iron wire. Select a soft pine board ⅞ inch thick about 3 feet long and 4 inches or 5 inches wide. Drive two nails to a depth of ½ inch in the board at a distance apart equaling twice the circumference of the oval formed by the two wooden discs, when measured by a string passed around the grooves. Starting at one nail (Fig. 7) wind the wire from one to the other, always winding in one direction; that is, so as to inclose the two nails in a narrow coil of wire. When the total number of strands equals 100 the ends are connected, and one nail is cautiously withdrawn from the board, keeping the wire still on it, and drawn taut (Fig. 8). Twist the strands into a rope, keeping them taut, and remove the remaining nail from the board. Both nails are now removed from the ends of the band, being careful not to disturb the loops formed by them. Thread the band through the glass tube, passing it around both pulleys and bringing the ends together between them. The two ends are linked together by threading a separate piece of the iron wire through and through them (Fig. 9), drawing tight after each threading, and connecting the ends of the wire by tying or twisting, as in the case of the band.

This completes the working parts of the detector, and any casing may be fitted to it and finished according to the ideas of the operator.

A good casing is made by fitting the sides and ends with ¾ inch hard wood strips extending ½ inch above the surface of the discs. This forms a box with the top open, and a nice looking instrument is made by attaching a glass door by hinges to cover it and protect the working parts from dust and injury (Fig. 10).

The ends of the primary coil are brought to binding posts in the side of the box nearest them, and those of the secondary connected to another pair of binding posts, one on each side of the first two. If desired, a false bottom of pressboard can be fitted beneath the discs, leaving only the coils and tube, magnet, band, and discs visible.

It will be noticed in the case herein cited that the winding stem is situated in the base of the instrument — a great inconvenience that can be remedied only by gears or ratchets; but this is hardly worth while, in view of the great advantage to be gained by using an eight-day clock, which, in addition to its ability for long running, usually has the winding stem on its face. The proper speed of the driving disc is that which will cause the moving band to complete the circuit through the tube in about two minutes.

Aerial and ground are connected to the terminals of the primary coil, and the telephone to those of the secondary. An almost inaudible hissing sound, in the telephone, as the band slowly threads its way through the tube and around the pulleys, shows the detector to be in working order.—*Scientific American.*

Mechanical Drawing

WILLIAM C. TERRY

The following problems are given to serve a double purpose: to teach the use of drawing instruments, and to point out those problems in practical geometry that are most useful in mechanical drawing, and to impress them upon the mind of the young draftsman so that he may readily apply them in practice. The principal thing to be aimed at in making these drawings is accuracy of construction. All dimensions or distances should be laid off carefully and correctly. Straight lines joining arcs should be exactly tangent, so that the joints cannot be noticed. It is the little things like these that make or mar a drawing, and if attended to or neglected they will make or mar the draftsman. The constant endeavor of the beginner should be to make every drawing he begins more accurate, quicker and better in every way than the preceding one. If these suggestions are faithfully followed, success awaits any one who earnestly desires it.

PROBLEM 1. *To bisect a straight line* A B *or an arc of a circle* A C B.

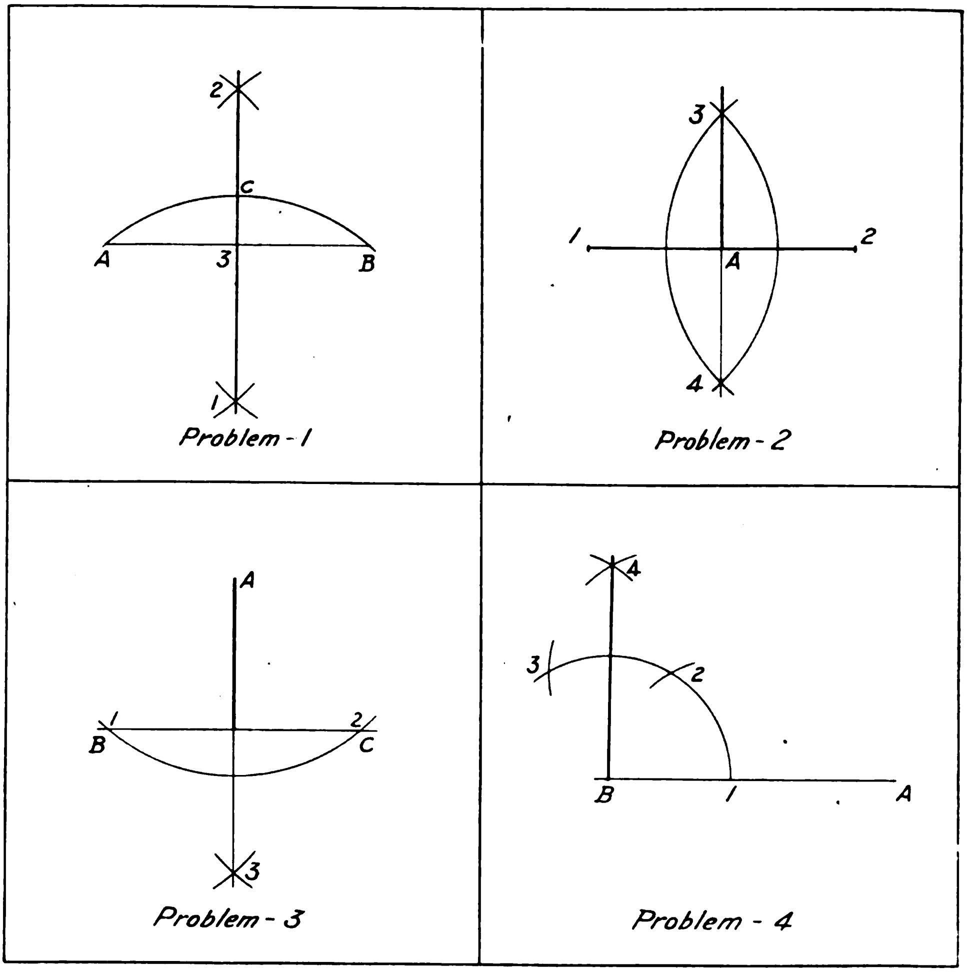
With B and B as centres and any radius greater than half A B, describe arcs which intersect at 1 and 2. Join 1 and 2 by a straight line, and 1-2 is perpendicular to A-B, and bisect it in 3, and the arc in C.

PROBLEM 2. *To erect a perpendicular to a given line at a given point* A *in that line.*

With A as a centre and any radius, set off equal distances A 1 and A 2 from A. From points 1 and 2 as centres, and with a radius greater than half 1-2, describe arcs which intersect in 3 and 4, join 3 and 4, and 3-4 is the required perpendicular.

PROBLEM 3. *To draw a perpendicular to a given line* B C, *from a point* A *outside the line.*

With A as centre and any radius, intersect the given line in points 1 and 2. With points 1 and 2 as centres and any



radius, describe arcs intersecting in 3. Join A and 3; A 3 is the required perpendicular.

PROBLEM 4. *To erect a perpendicular to a given line* A B, *from a point* B, *at or near its end.*

With B as centre and any radius, draw an arc of a circle 1-2-3 With 1 as a centre and the same radius, cut this arc in 2, and with 2 as centre and the same radius, describe the arc 3-4. With 3 as centre and the same radius, intersect 3-4 in 4. Join 4 B; this is the required perpendicular.

PROBLEM 5. *To draw a line,* E F, *parallel to a given line,* A B, *and the distance* C D *from it.*

From any two points, A and B, in the line as centres, with radius C D, describe arcs E and F. Erect perpendiculars at A and B, which intersect the arcs in E and F. Join E and F; this is the required parallel. In practice it is not necessary to draw the perpendiculars.

PROBLEM 6. *To construct an equilateral triangle on a given base,* A B.

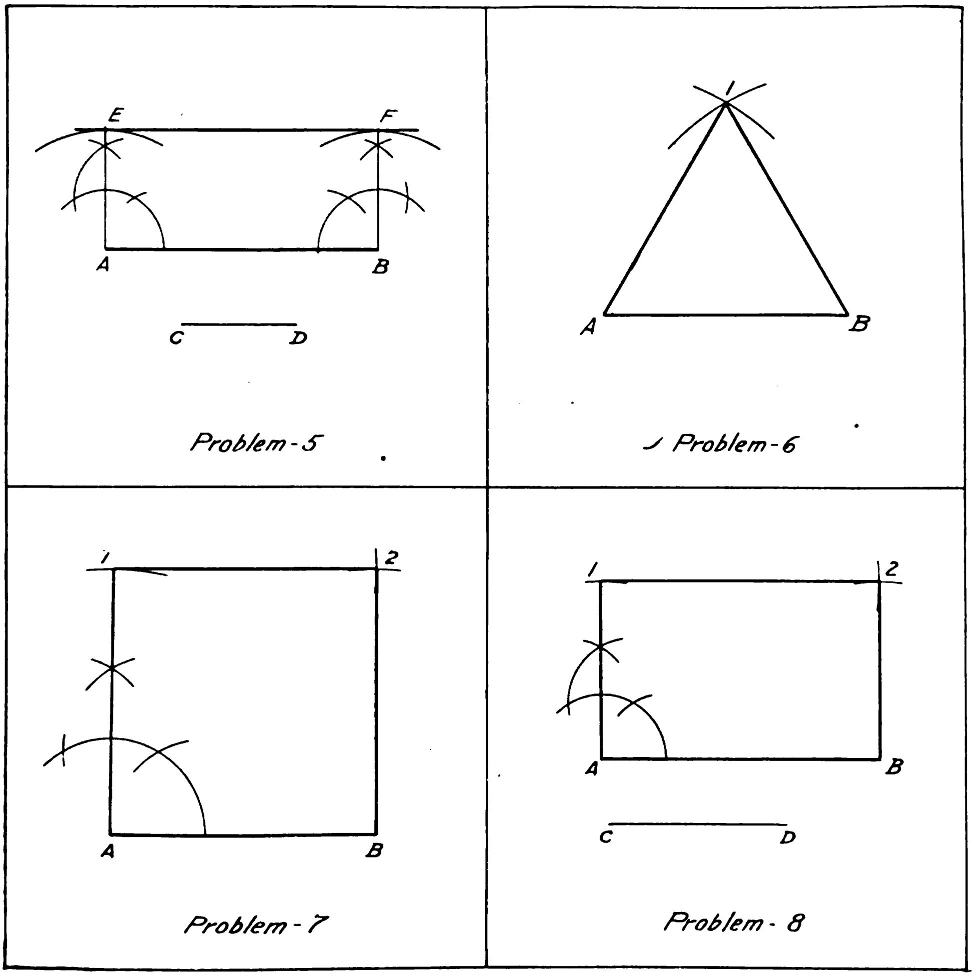
With A and B as centres and A B as radius, describe arcs which intersect at 1. Join 1 A and 1 B.

PROBLEM 7. *To construct a square on a given base,* A B.

Draw A 1 perpendicular to A B and equal to it (Problem 4), with B and 1 as centres and radius A B, describe arcs intersecting in 2. Join 1-2 and 2 B.

PROBLEM 8. *To construct a rectangle of given sides,* A B *and* C D.

At A, by problem 4, erect a perpendicular A 1 equal to C D. With 1 as centre and radius A B, describe an arc, and in-



tersect this arc in 2, by one described from B with C D as radius. Join 1-2 and 2 B.

Problem 9. *To bisect a given angle,* C A B.

With A as centre and any radius, describe an arc intersecting A C and A B in points 1 and 2. With points 1 and 2 as centres and any radius, describe arcs which intersect in 3. Join A and 3.

Problem 10. *To trisect a right angle,* C A B.

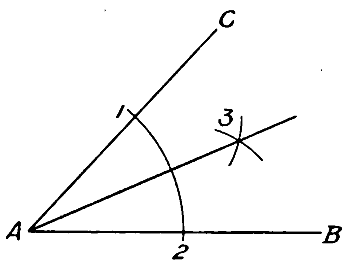
With A as centre and any radius, describe an arc intersecting A C in 1 and A B in 2. With 1 and 2 as centres and the same radius, intersect the arc in 3 and 4. Join A 4 and A 3.

Problem 11. *To construct at* E, *in the line* E D, *an angle equal to a given angle,* A B C.

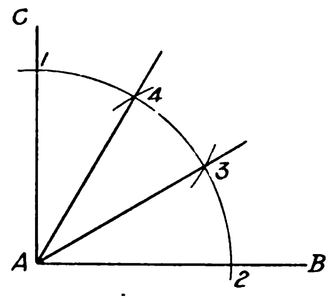
With B as centre and any radius, intersect A B and B C in 1 and 2. With E as centre and same radius, describe an arc intersecting E D in 4. With 4 as centre and 1-2 as radius, intersect the arc in 3. Join E and 3.

Problem 12. *To inscribe a regular hexagon within a given circle.*

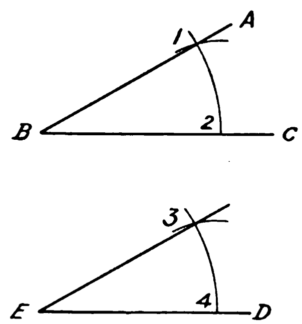
Draw the diameter A B of the circle, which will be a long diagonal of the hexagon. With point A as centre and the radius of the circle as radius, intersect the circle by arcs 1 and 2. With B as centre and same radius, intersect the circle by arcs 3 and 4. Join A-1, 1-3, 3-B, B-4, 4-2, and 2-A.



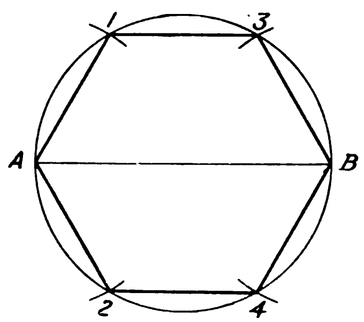
Problem-9



Problem 10



Problem-11



Problem-12

BOOK REVIEWS

ELECTRICAL APPARATUS, Simply Explained. The Model Engineer Series, No. 31. Percival Marshall & Co., London. 80 pages. Price, 6d.

In this introductory book, the alphabetical arrangement of topics has been followed, resulting in a convenient rather than logical development of the subject. Thus, "arc lamp, accumulator, alternating current, ampere, battery, circuit, dynamo, electromotor, electroplating, fuse, induction coil, resistance, transformer, and volt," form the principal headings. The book is carefully written by some one evidently familiar with the subjects, and laboring with considerable success to condense a large amount of information, worded to fit a layman, into a small space.

The illustrations are numerous and of good size, while the diagrams of connections are clear and usually sufficient. The one on page 10, however, purporting to show arc lamps in parallel, is a little in error, for it is really a series-parallel arrangement; while it represents two parallel circuits, each one of these consists of four lamps in series. Further, the supply is denoted as at 200 volts, whereas with suitable allowance for the insertion of series-steadying resistances,—absolutely necessary with a constant potential supply,—only three open arcs, or two of the enclosed sort, could actually be operated. A person literally following the diagram as shown would quickly come to grief.

From such a brief treatise many omissions are to be expected, but reference to such important topics as recording watt-meters, switchboards, and incandescent lamps would have been eminently proper. On the whole, it is considerable of a publication to sell for twenty-five cents.

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EDITORIALS

We are planning soon to increase our subscription price from 50 cents to $1.00 a year. Those who have found the magazine helpful and instructive we urge to subscribe now for the forthcoming years. If you subscribe before the change we will send you the magazine for one year and any 25-cent book for 60 cents; one year and any 50-cent book for 85 cents; one year and any dollar book for $1.35.

The price after the change, which will occur shortly, is to be $1.00 to subscribers in the United States, Mexico, Cuba, Porto Rico, Canal Zone, Tutila, Hawaii, Guam, Philippines and American post offices in China, $1.25 to Canada, and $1.50 to other foreign countries.

Our readers have all, no doubt, looked over with interest the index for Volume XVII. which was sent with our June number. All the articles and authors were listed, also the topics contained in our valuable Questions and Answers department.

We will send a copy of this index free on request to any reader who did not receive one.

We can supply a few more bound and unbound volumes from July, '06, to and including June, '07, to those desiring the back numbers. Price, bound in red buckram, $1.25; unbound, $2.00. A few single copies at prices listed in June number can still be bought.

Will you not act as agents for us and assist us to increase our circulation so we can give you a better and bigger magazine with more useful knowledge, thus helping a great number to work more intelligently and in many cases to assist in increasing salaries. For every 50-cent yearly subscription we will give one of our 25-cent books, for two years' subscriptions either to the same person or two different persons we will give two 25-cent or one 50-cent book. Three yearly 50-cent subscriptions, books to value of 75 cents; and four, a $1.00 book or its value. This does not apply to your own personal subscription — it must be that of some one whom you have solicited.

We publish this month a timely article on Photography by J. Horace McFarland, a well-known authority on the subject. We had hoped to resume this month, in deference to the many requests for articles on photography received in our recent contest, the series of articles for beginners which we ran for several months. This will be carried over to a future number, however, on account of the absence of the author in Europe. Other articles will be presented from month to month as available. We have on our staff a specialist in photography, and shall be very glad to answer questions on any photographic subject, whether simple or complicated. Any of our photographic readers who desire to have their pictures criticised both artistically and technically, with suggestions for improvement in their work, may have this done if they will send unmounted prints, accompanied by return postage, to this office.

It is remarkable the number of books on electrical and other scientific subjects which we have been supplying to our readers during the past few months. The satisfaction which has been shown us by numerous letters, assures us that this branch of our business is very gratefully received. It has been impossible to keep some of the more popoular works on our shelves, and we have, therefore, had to re-order either through other houses or from abroad.

We regret exceedingly that our Magazine for this month is appearing so late. Owing to complications at the printing plant it has been unavoidable.

The Camera in Summer, and Suggestions as to How to Avoid Certain Failures

BY J. HORACE MC FARLAND

The camera in summer? What else comes to mind but a shoulder-strapped or pocket-carried little convenience with its easy facility of roll-film or film-pack, tempting to constant experiments and thoughtless exposures.

I admire, and recurrently desire, these delightful little apparatuses which entice us under attractive names and at ridiculously low prices. Triumphs of ingenuity, marvels of compactness, wonders of lightness, they are; and in trained hands, guided by skilled brains, splendidly efficient as well. But how seldom is the summer camera, by sea or shore, at lake or mountain, efficiently handled, and satisfactorily used? One summer I had opportunity to see each day, at a resort developing station, the rolls and packs of developed film as completed, and the failures made visible. Not two per cent. of successes were in evidence! Every fault of carelessness, inexperience and reckless disregard of conditions was before me every day, and it was a rare and pleasant surprise lto see, occasionally, a roll showing realy good results. The developing operator, a capable young man, would be in ecstacies when this occasional event happened, for then he knew there would be a break in the disagreeable explanation so monotonously and continually to be made to the camera owner. Usually it would go:

"Yes miss; your films are ready. No; I didn't make any prints of them; I thought you had better see the films first. I think you must have been making snap-shots indoors, for you notice there is hardly anything on the film? You didn't know you had to give time exposures inside? One of the films seems to show several images; perhaps you forgot to wind off after making an exposure?

And away goes Miss Summer Camerist, possibly saying: "The hateful fellow! I just know he spoiled my films on purpose! And isn't it a shame they don't sell us better films?"

I have often wondered what happened when a certain film was developed, exposed from one of the most majestic view-points in the Adirondacks. The day was one of great glory, with rich, fleecy clouds adding to the distance and charm of the blue mountain-tops, ranged in every direction. The "light," as the photographer calls it, was "round" in his vocabulary, and "fast," as well, and the famous amateur who told him the story was wondering whether he ought not to use a ray-filter to "slow" it, so he could safely work with an exposure of about a fiftieth of a second. Just then there arrived at the same vantage point Miss American Summer Girl, charming, self-possessed, and accompanied by an admiring swain. He carried the dainty little camera, planned for photographs about the size of the palm of her rose-leaf hand.

"Oh, how fine! I will photograph it! Bring the camera *here*, George! Yes, you may hold it in *your* hands! Let me see—what is the right exposure? Oh, yes, there is so much of the view, so it will take longer! About *three* minutes will be right, George!

So Miss A. S. G. holds the watch, and George holds the camera, for three minutes! In equal blissful ignorance they work, and the only certainty is that there will be uniform blackness on the film and undoubted consequent objurgation upon the film-maker and the developer.

But the camera in summer may be made to bring great satisfaction to its users, if they use it with plan and purpose, and with common sense. While many experienced workers prefer to carry comparatively heavy cameras, making photographs of the larger sizes, others just as capable secure admirable and most pleasing results with the smaller instruments—and a good small negative may readily be enlarged. The most of the "pocket" cameras will make excellent negatives if properly handled. I may as well say, too, that the finest lenses are not essential, though desirable. Many a success has been made with a cheap lens, and the best modern gathering of glasses, possesing. every good quality that a lens should have, cannot make up for carelessness or inexperience on the part of the user.

The first requisite is a reasonable understanding of the camera to be used. Examine it carefully, noting the various parts and their uses. There will be, on a camera to use film only, a lens, which is set in a "shutter," and attached at the small end of a bellows, unless the camera is of the box type, in which case the length of the box represents the bellows. In the lens or shutter there will be "stops" or "diaphragms," designed to regulate the amount of light to be admitted through the lens to record the view or image on the sensitive film or plate. At the larger end of the box there will be an arrangement for maintaining and changing the sensitive film, whether it be in rolls, or in "packs" of cut pieces, or spread on glass plates.

To understand the reason for many failures, let us compare the lens of the little camera with the lens of the human eye. The latter wonderful instrument projects an image on the retina, to be comprehended by the brain, as if it were at the end of a bellows about sixteen inches long when looking at objects more than a hundred feet away. All our impressions of what we see are made by this instrument, this lens. *These* lenses, I should say, referring to the two eyes we are born with, add, by reason of their separation, the quality of roundness to what we see. That is, we see stereoscopically, with a pair of matched sixteen-inch lenses, marvelously arranged so that the change of focus required to bring nearer objects into sharp appreciation is effected by a mere effort of will, which governs the muscles that change the metaphorical bellows between the eye-lenses and the retina-film.

How clumsy is the humanly-made lens in comparison! Your little pocket camera has a lens of but five or six inches focal length, which means that it sees a wider angle than the eye, and sees it smaller — as much smaller, in proportion as the difference between five or six and sixteen. Now can you understand why that glorious mountain view you saw, vast and impressive in its distance, or that speeding yacht which passed your steamer but a half-mile away, last summer, became so utterly commonplace and trifling, to your disappointment, on the snap-shot you made? You cannot condense a third of the horizon onto a four-inch film and have it impressive.

I remember how I first learned this fact, the summer I first had a camera. It was one of the orignal Kodaks, making a round picture two-and-a-half inches in diameter. A visit to a vantage point in the beautiful Cornwall hills of Pennsylvania gave me a splendid panorama of peaceful valley and mountain, rich with foliage. I resolved to bring away a lasting impression; so I gravely snapped my little camera at the four points of the compass. Only when the utterly flat result was before me did I realize that a total of ten inches of film was somewhat inadequate to record in impressive detail the scenic beauty of a circle of twenty-five miles radius.

So let us not be deceived in our summer's work. The little camera will tell us many delightful stories if we will but use it according to its powers. When we pull out its bellows to the "universal" focus (75 or 100 feet and beyond), it includes an angle of view about like this: **V**. Your eyes see an angle of view about like this: V. Now if the wider extent of view included in the wider angle is condensed to go on the little film, it will be smaller, in proportion, than the view your eyes see with the narrow angle, won't it? It is condensed, squeezed together.

The moral of all this is, to use the small camera—4 x 5 and under—only for intimate, near-by summer notes, unless there is a great object in the distance which will bear the condensing of the wider angle.

There is another analogy to the human eye which will help the summer camerist. We all know how large the eyes of a cat look in the dark, and how they are narrowed to a mere slit in the sunshine. If any one will take the trouble to go quickly from a sunny outdoors to a room which is lighted by artificial illumination only, he will note a surprising dimness in the room, which will soon disappear as the eyes become accustomed to the change. When he sees clearly, the same change will have been made in his eyes as in the cat's eyes — they are simply wider open in the comparative dimness of indoors.

The lens is an eye, a window, to admit light to the sensitive film or plate. The film is as sensitive as the science of chemistry will permit it to be, so far — and how that science has increased sensitiveness may be realized when one remembers that Daguerre exposed his plates twenty minutes to make a picture that your film will take as fully in the fiftieth of a second! Now, to have the light reach the plate in the right quantity, the lens and shutter people have arranged "stops" or "diaphragms," which present openings of various diameters to the entering light. In the cat's eye and in the man's eye, this apparatus is called the iris; and it acts involuntarily, requiring no conscious brain signal.

But the camera diaphragm—and it is sometimes an iris diaphragm, too—must be actuated by the brain of the operator through his fingers. Judgment in using the "stops" according to the light will greatly help the summer picture-making. On the ocean, or at the seashore, where there is the vast reflection of the water on the sands, the opening must be made smaller, just as the operator's eye closes to the excessive light. In the woods, or among lawn trees, or inside a house, the eye opens fully—and so must the lens within certain limits. Moreover, the brain (and it will be noted that I am arguing for the use and the cultivation of the sometimes neglected brain in connection with summer photography) will have to take into account much greater variations in the light than those that can be controlled by the stops. The properly operated shutter attends to this, and while a small stop and a fiftieth of a second at the seashore may be a full exposure on a bright day, the open lens and two or three seconds will hardly suffice in the woods.

The stops perform another function of which I may barely hint. Greater depth of focus — that is, more uniform sharpness in the photograph — is attained in the use of the smaller openings. With the little cameras we have been discussing, using lenses of six inches focal length or less, this property is not so important.

I have mentioned two points, ignorance upon which causes many failures. There are many others; but understanding of them will come by experience, if the brain checks the experience gained and does not leave it all to be suffered by the purse.

A definite aim in summer photography will add immeasurably to the experience and the probability of pleasing results. Take up some one thing and make it a "hobby." For myself, I confess to little interest in general and indiscriminate snap-shotting. I want a tripod camera, and plates; and I am willing to endure failures in riding my hobby, which is the picturing of native trees and plants where they live, in the woods and fields. — *Suburban Life*.

Demagnetization of Tools, Watches, etc.

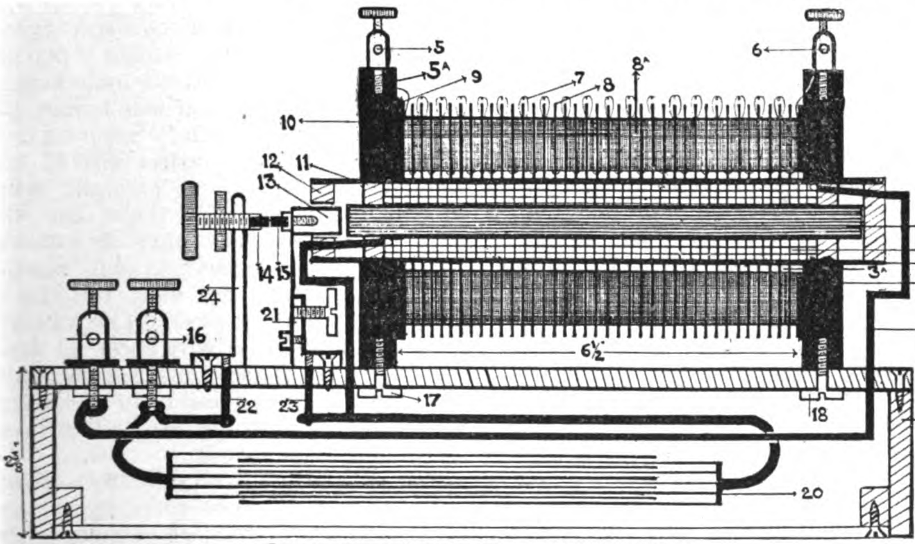
A process by which tools and watches can be perfectly demagnetized is as follows: An alternating current is carried through a coil of copper wire, shaped cylindrically inside and conically outside. The magnetized object is introduced into the coil, slowly, from the top, and slowly drawn out again. The theory of the process is that when the object is put into the coil, a change in its polarity takes place with each change in the current; when it is removed, the magnetism becomes gradually less, because few lines of magnetic force pass through it. With one turn or winding of the coil the magnetism is not measurable. A magnetic steel tool is inconvenient for use on iron because the filings cling to it. This state of magnetism is often found in turning lathes, where the coils of wire for dynamos are wound. If it once begins, each day finds some other tool in the same condition, until calipers, turning tools, squares, etc., all cling together and attract small screws and filings. To demagnetize the lathe centres, which are the principal cause of this trouble, an apparatus is used consisting of a hollow coil or roll of copper wire connected with an electric lamp socket. An alternating current is passed through the coil and into the magnetic object. The current will correct the condition, if there is enough resistance of the coil.—*Scientific American*.

The Construction of a 4-inch Spark Coil

BY B. A. HUNT

The materials and tools required are simple and few in number. The ordinary light wood and metal working tools possessed by the average amateur should suffice to turn out a well-finished and efficient coil. The aid of a lathe will greatly facilitate the construction, but it is by no means indispensable. It would be well for the amateur to read up the theory of the induction coil in a good electrical text-book if he does not already thoroughly understand it.

The secret of building a good coil with the minimum amount of secondary wire, is to have it most thoroughly insulated and well arranged with regard to its primary winding. The best method of insulating the wire is rather a tedious one, but it will well repay by results for the time and care spent upon it. The following method of construction was adopted by the writer, and the finished coil gave results equal to, if not better than a coil by one of the standard makers, and at a cost of materials of about $25.00.



LONGITUDINAL SECTION OF A 4-INCH SPARK COIL.

The first thing to do will be to obtain all the materials. Several firms advertising in this paper will supply the amateur's needs capitally. The most expensive item will be the secondary wire: obtain 4½ lbs. s.c.c. wire, No. 36 gauge; this is about $4.00 per lb. (silk insulation is unnecessary); for the primary, 1 lb. No. 14 D C.C. wire, at 80 cts. per lb.; 1 lb. thin tinfoil, at 75 cts. per lb.; one piece of ebonite tube, 8¾ ins. long by 1⅝ ins. diam. outside and ⅛ in. thick, 50 cts.; two pieces of ½ in. sheet ebonite, 4¼ ins. by 4⅝ ins., at 60 cts.; ¾ lb. No. 22 soft iron wire, 25 cts.; 1½ quires white filter paper (obtain at chemical warehouse), 50 cts.; ⅜ in. of No. 16 platinum wire, at $2.00; two large galvanometer terminals, two small ditto, at 10 cts. each; a few sq. ins. of 3 16ths in. sheet brass, 15 cts.; 4 ins of ½ in. width clock spring; one long contact screw (and, if possible, a lock nut); one piece of soft iron rod, ⅝ in. diam. and 1 in. long; four 3 16ths in. metal screws, 1¼ ins long; two ⅛ in. metal screws, ½ in. long; two 3 16th in. screws (brass), ¾ in. long; two dozen assorted wood screws, ⅜ in. to ¾ in. long, about 50 cts. the lot; a few square feet of ⅜ in. baywood, or good pine, for the base, 50 cts.; 2 lbs. paraffin wax, about 15 cts. per lb.; solder, resin, and shellac varnish. These quantities are a liberal allowance for a coil this size, and are intended only as a guide for the amateur.

MAKING THE PARTS

First, the Baseboard (Fig. 19).—This is in the form of a shallow box, 12½ ins.

by 7¾ ins. by 2⅜ in. deep. It will be a fairly simple piece of work; the joints being either screwed or dovetailed together, according to the skill of the worker. The main thing is to make it strong and square. Smooth up the sides and top well, so that it can be varnished It will be seen from the sketch that the underside is covered in by a thin, well-fitting board. This is fixed by screws to fillets glued into the corner of the box.

The Coil Ends (Figs. 4 and 10).—The best possible material for these is ebonite, although paraffined teak would make a good substitute. These must be nicely filed up to size, and the edges and surfaces finished off with fine emery cloth and oil. Then bore a 1⅝ ins. hole (a good fit for ebonite tube) a little above the centre as sketched. This can be done in the lathe or by means of a fret saw, finishing off true with a half round file. Two holes must now be drilled in the lower edges and tapped for a 3 16ths in. screw; also one hole in the top edge for the terminals of secondary wire.

The Insulating Tube (Fig. 3) must be obtained cut to size, straight and circular; be very careful that no minute holes perforate the walls. This would cause a speedy breakdown of the coil. If an ebonite tube cannot be obtained, make one by wrapping thin "paper" ebonite round a mandrel, cementing each layer with shellac varnish.

The Soft Iron Wire Core (Fig. 1).—Cut the hank of 22 iron wire into 8 in. lengths; straighten and make into a neat round bundle, ⅞ in. in diameter. Next pour some shellac varnish down between the wires and dry in the oven. Two wood flanges must now be made (Fig. 11) so as to fit the core tight at the ends and slip easily into the ebonite tube. Fix on tight so as to leave a space of 7 ins. between them. A layer of paper should now be cemented round the core, and three layers of No. 14 D.C.C. wire wound in the space. Two small holes will require to be drilled, one at each end, 12 ins. of the wire being passed through the hole close to the core from the inside; the end of the third layer is brought out through the hole drilled in the edge of the opposite flange. Keep the winding as close and tight as possible, and finally give it a coat of shellac varnish.

The Secondary Sections (Fig. 8).—A section winder will be required for making these. This will be understood by looking at the sketch. It consists of two discs of hard wood 3¾ ins. diameter, separated an ⅛ in. by a disc of metal 1 13-16ths ins. diameter. The three are fixed upon a screw spindle and clamped together by nuts. This has now to be mounted in uprights secured to a wood base. A small handle is bent or attached to the end of the spindle. This being made, the bobbins of No. 36 wire must be well saturated with hot paraffin. This will best be done by obtaining a metal vessel deep enough to hold the bobbin. Melt the paraffin carefully in it (avoid over heating it), and then immerse the bobbin in it till no more air bubbles are driven out; the bobbin may then be hung up to drain. Now fix the winder securely to the table and fix a stout wire horizontally and about two feet above the table. On this the bobbin is placed, and a Bunsen burner fixed underneath; the hot air rising from it will render the paraffin on the wire soft. Secure a turn of wire around the centre disc of the winder, and proceed to carefully wind till the space is full. Then cut the wire and remove the inner disc of the winder; the wire section will readily come away from the disc, this being tapered for the purpose. The wax will reset on the turns of wire and hold them quite firm. Forty sections must be made, and it would be advisable to test them for continuity with battery and galvanometer before mounting.

The Insulating Discs (Fig. 8).—These are to be made from filter paper, and soaked in paraffin wax. For melting the wax obtain a shallow baking tin, which should not be less than 11 ins. by 7 ins. As the condenser sheets will also require paraffining, make a true cardboard gauge 4 ins. diam. by 1⅝ ins. hole in centre; place this over a number of the sheets together, and cut through with a sharp penknife. About ninety discs will be required. Next have the paraffin nicely melted, and soak the discs in it; take them out one at a time, allow to set for an instant, and then place them on a clean sheet of paper to cool. It is important that no dust or metallic particles adhere to the surfaces.

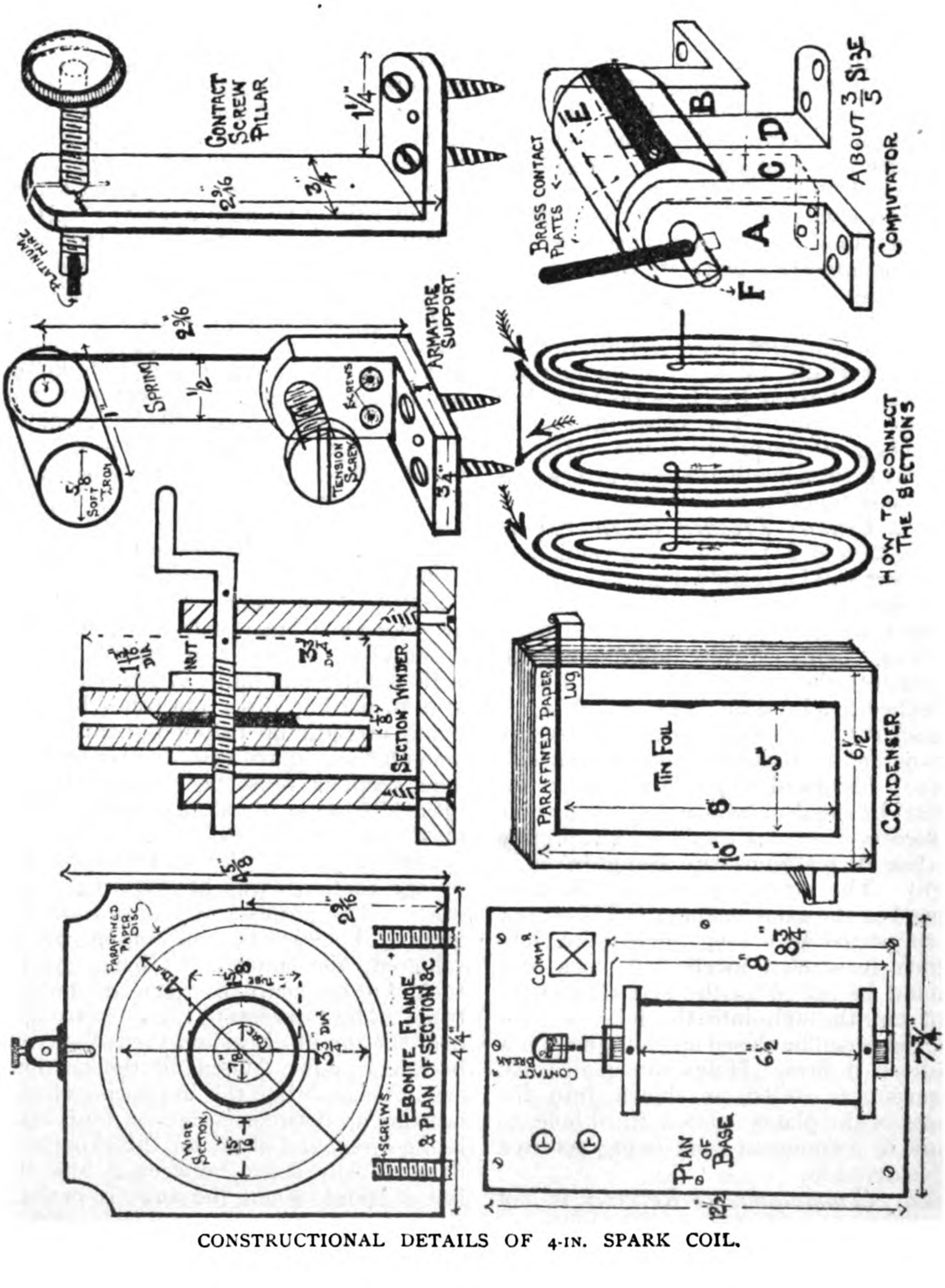
The Condenser (Fig. 20) consists of sixty sheets of paraffined paper, interleaved with tinfoil. Cut the papers 10 ins. by 6½ ins., and paraffin them as before. The foil sheets must be cut to size (8 ins. by 5 ins.), with a connecting lug as sketched. This is best done by first cutting the sheet ½ in. longer and slitting it across to within 1 in. of the edge, then simply bend back the lug thus formed. Proceed to build up the condenser by first cutting two pieces of cardboard 10 ins. by 6½ ins. Lay one flat on a level table; on top place a sheet of paraffined paper; next place a foil sheet symmetrical with it, with its lug projecting over the edge; over this a paper sheet, next a foil sheet, with its lug at the opposite lower corner, and so on alternatively, till the full number are built up. Fasten the lugs on each side firmly together. The other cardboard sheet is now to be placed on top. Heavily weight it for some hours, and afterwards tie firmly together with tape.

The Contact Breaker or Interrupter (Figs. 21 and 24).—The construction of this part will be readily understood from the sketch. The soft iron armature is made from a piece of ⅝ in. round iron, 1 in. long. This is drilled and tapped and secured to the spring, this being rigidly attached to a brass angle plate. A screw passes through so as to press against the spring and increase the tension if necessary. The head of the armature screw must be filed down, and a small hole drilled in its centre to allow a small piece of No. 16 platinum wire being driven in tight. The contact screw end must be tipped in the same manner. This screw is supported by a long angle-piece, into which it screws nicely. A lock nut should be added to the screw, or else a slot cut through into the hole, so that the sides can be closed up on to the screw to keep it firm. Holes for small wood screws are drilled, as shown, into the bases of the plates; also a third hole, to allow of a connecting-pin being screwed or soldered in.

The Commutator, or Reverser, is not really necessary, but is a useful addition to the coil. The form illustrated is as good as any. It consists of a short cylinder of ebonite or hard wood (E), through the centre of which passes a brass pin (F). This is really in two parts, so as to be insulated from each other. Two contact plates are screwed to opposite sides of the cylinders, and one put into contact with each of the pins by a screw passing through. The cylinder is supported by two angle-pieces (A and B) and two brass springs (C and D), arranged to press against the contact plates. An ebonite or brass handle is attached to the spindle. Plates A and B join the terminals, and the springs C and D are attached—one to the free end of the primary coil and the other to the contact screw. It will readily be seen that the springs C and D can be put into contact with either poles of the battery, at will, by simply turning the cylinder round.

Fitting the Parts Together—The most important detail is to build up the secondary. For this a small vessel of melted paraffin, soldering iron, solder, resin, and a warm laundry iron will be required. Have all the discs and sections at hand, and fix the ebonite tube into one of its flanges, so as to pass through ¾ in., and stand it up vertical. Slip three or four paper discs over the tube and flat against the flange; then fix a section in position, withdraw inner end of the wire and arrange it concentric with the tube. The space (Fig. 3A) must be filled up solid with melted paraffin. When set, place two insulating discs on top (the wire being brought up through them); then smooth them down with the warm iron. The sections must be connected—two insides together, then two outsides, then insides, and so on. Be most careful to get the proper face down, otherwise some of the sections will be opposing each other. The proper way is shown on diagram. The joints will require to be soldered, the inner joint being neatly tucked in the space between section and tube. The outer joint (Fig. 7) is brought over the top of discs, and then slipped in between them. When all the sections are in place, bring the inner end of the last one up between three or four insulating discs, and place on the other coil flange. Any space between it and the last sections, when the tube is projecting through equally on each side, should be filled in with more paraffined discs. Two small holes are now to be drilled slantwise up through the flange to the terminals 5 and 6, and the secondary wires passed through and joined to them.

The position of the fastening down holes on the base is now to be found,



CONSTRUCTIONAL DETAILS OF 4-IN. SPARK COIL.

and the holes drilled to allow the screws to pass through into the holes in the flanges (Figs. 17 and 18). The primary is now slipped into the tube, and two tight fitting end pieces of wood (Fig 12) made to fit the tube. One must have a ¾ in. hole drilled through its centre (Fig. 12), and both will require small holes drilling to pass the primary wires through. These are then taken through holes in the baseboard. The contact breaker should now be fixed in position, as shown on the diagram, and the end of the wire nearest soldered to the brass pin in the armature support. The contact screw is taken direct to one of the large terminals (Fig. 16), the other terminal making contact to the free end of the primary (Fig. 4A). The lugs of the condenser are put in contact, one to each (contact pillar and spring). Make a good connection to foil lugs by wrapping some No. 24 tinned copper wire tightly round them and making a soldered connection to each of the pins 22 and 23. The condenser can be wedged in place with a few strips of wood and the wood base cover screwed on, when all is secured inside.

The covering for the secondary consists best of "paper" ebonite, cut to a good fit between the flanges and made to overlap about 1 in. The lap is cemented with strong shellac varnish, a few turns of string keeping it in place till set. An excellent substitute for ebonite is paraffined cartridge paper, fixed in the same way, afterwards varnished black. The coil can now be tested. Arrange the armature to be about 3 16ths in. from the bore, and adjust the contact screw, so that when the armature touches the core the circuit is broken 1-32d in. Next fix a short piece of wire in each secondary terminal, so that they stand 4 ins. apart. On connecting three large bichromate cells in series onto the primary terminals, the interrupter should vibrate and produce a torrent of sparks between secondary terminals. If the full length of spark is not obtained right off, try putting more or less tension on the armature spring till successful. No difficulty should occur in obtaining a full 4¼ in. spark if the directions are closely followed. If storage batteries are used to work the coil place a small resistance in series, otherwise the platinum contacts will burn away quickly, due to the heavy current on short circuiting at the contacts; also be careful not to overwork the coil with too many cells.

The appearance of the coil will be greatly improved by finishing off the brass work, such as the contact breaker, commutator, and terminals, to as high a polish as possible; then lacquer the parts with silico enamel or cold white lacquer. The commutator, if used, is best placed in the position shown on the baseboard plan.

A word of warning should also be given, against using the coil on high voltage circuits with the electrolytic interruptor. The insulator is almost certain to be broken down if the current is kept on more than a few seconds. This is due to the intense pressure induced in in the secondary, and as the current is also fairly heavy (1-10th to 1-5th amp.) for the wire to carry, it warms it up and softens the paraffin, and thereby allows a spark to perforate it.

Duration of Lightning Flashes.

We possess as yet only pretty vague data as to the average duration of flashes of lightning, says L'Illustration. Faraday thought he could fix it at a second. Dufour claimed that the flashes of lightning were instantaneous, and that their rapid succession gave the illusion of one flash of a certain duration. Herr Schmidt has just been devoting himself to a series of observations, employing a disc of ten centimetres diameter bearing upon a black ground a white cross, the arms of which were two millimetres across, the disc being set in motion by clockwork with a speed of fifty to sixty revolutions a second. At certain flashes the cross appeared a single time very distinct; the duration of lightning was, therefore, inferior to the time of revolution of the disc, which would represent about the fiftieth of a second. In more numerous cases the cross appeared two or three times, or even more, but with a decreasing luminous intensity. The lightning had, therefore, lasted during several revolutions of the disc.

QUESTIONS AND ANSWERS

[Subscribers are invited to use this department. All questions on electrical and scientific subjects of a practical nature and of general interest will receive attention. The writer must give his name in full, but nothing that may identify him will be published with a question if he requests his name withheld. It will give the editors pleasure to assist, through this column, all subscribers, if possible, and they cordially solicit practical queries. **Questions must be written only on one side of the sheet, on a sheet of paper separate from all other contents of letter, and only three questions should be sent in at one time.**

Parties wishing special answers to questions by mail must inclose $1.00 or more, depending upon the amount of labor entailed in answering the same, for trouble and expense.]

Dry Storage Battery—Induction Motor

276. E. H., Eden, Ill., asks (1) How to make dry or semi-dry storage cells with Faure plates? (2) What is the principle of operation of an induction motor? (3) Is there a 25c pamphlet describing how to make such a motor?

Ans. (1) Storage cells must be of the wet kind, and very wet at that,—there must be a surplus of electrolyte. (2) There will soon be a good article on this subject in the Electrical Engineering chapters. (3) No, the cheapest book is a $3.00 book. In general, the stationary part of such a motor must be made of sheet iron, and the winding is rather difficult for an amateur to comprehend.

Dry Cell Renewals

277. C. R. W., Winooski, Vt., asks (1) If a Columbia dry cell can be renewed by following the directions given in the November issue? (2) If a five-bar telephone generator was rewound with No. 24 wire, what current would be allowable, and how much power would be required to drive the armature?

Ans. We have never analyzed the contents of a Columbia cell, but the filling referred to will answer. (2) 1 to 2 amperes. ¼ h.p.

Telegraph

278. A. I. B., Marlin, Tex., asks (1) How many batteries, and what kind should be used on a telegraph line 600 feet long, with a ground return? (2) How can a permanent magnet be made capable of lifting three pounds? (3) What is the difference between a direct and an alternating current?

Ans. With the Morse closed circuit method use three gravity cells, at either end of the line; with open circuit method, use three dry cells at each end. (2) See answer No. 132 in February issue. (3) You will find chapter II. in the August issue very helpful to an understanding of this distinction.

Gasoline Engine

279. J. S., Merrick, Okla., asks (1) What is the reason for making the piston rings of an engine thinner at the ends where the cut is than at the opposite part. (2) What size of lathe would be needed to build a 2½ h.p. gasoline engine? (3) What is the best way to space the slots for a toothed armature?

Ans. (1) This is to allow for uniform bending. Were the ring of uniform section, the bending would be mostly on the side opposite the cut. By making the ends tapering, the pressure to maintain tightness is a minimum. (2) Except for turning the balance wheels, a lathe swinging 16″ would suffice. You might be able to purchase the wheels already turned. Address the Chicago House Wrecking Co. See article in February issue, pages 237 and 238.

Carbons

280. I. F., Montevideo, Minn., asks if the carbons of exhausted dry cells can be removed and used in ordinary liquid cells?

Ans. Yes. It would be well, however, to clean them by boiling in water.

Small Dynamo

281. W. C. B., Knoxville, Tenn., is making a small dynamo. Field cores are 1″ x 2″ and 3″ long. Armature is 3″ long 3″ dia. with 12 slots. What would be a good winding?

Ans. You do not state any particular use of machine, so we would advise a low voltage winding, say for 10 volts, as being easy to put on. No. 18 for armature, and No. 21 for shunt field,—put on all you can.

Direct to Alternating

282. L. R. V., Bloomsburg, Pa., asks how to change a No. 5 K. & D. 6-volt 6-ampere motor so as to make it run on a 110-volt alternating current circuit.

Ans. It cannot be done.

Old Storage Battery

283. G. H. F., Humboldt, Tenn., has a storage battery that has been out of use for more than a

year. The dimensions are 14″ x 8″ x 8″, and it weighs 50 lbs. It is practically "dead." What can be done to restore it to good working condition?

Ans. You do not state whether it is a portable cell enclosed in a wooden box, in which case it might really consist of three small cells, or if the figures given are the dimensions of a single glass jar. In any case, the plates should be removed from containing vessel, washed under a faucet, and the jar cleaned. Do not throw away any solution, but make it in quantity sufficient to cover the plates, and of density as shown by a hydrometer of 1.2. If the negative plates, the more numerous ones, are white, they are badly sulphated, and this must be removed by charging the battery in reverse direction until all signs of it disappear. Then allow the cell to discharge slowly through a resistance, and then charge it in the proper direction for a week. When fully charged the voltmeter will read 2.6.

Water Motor

284. L. H. W., asks (1) What horse-power could be obtained from a water motor supplied through a 2″ pipe from a tank 40 ft. high? (2) What would be the size and weight of a storage battery capable of supplying 6-horse power for one hour? (3) Where does the accent belong in the words telegraphy and telephony?

Ans. (1) If the pipe was smooth and without elbows, perhaps ¼ h.p.; the pressure at most would be but 18 lbs., and that is rather low. (2) With a 110-volt motor you would need about 60 cells, each with 7 plates 8″ × 8″; each cell would weigh about 50 lbs. (3) On the syllables "leg" and "leph"; although at first attempt, the pronounciation seems a little strained, the sound is very flat if accent is placed on next syllables.

Naphtha

285. S. K. H., Morristown, Ind., asks (1) Where can he obtain coal-tar naphtha? (2) Where ⅛″ dia. hard rubber rods? (3) Where gutta-percha in sheets? (4) How thick is No. 14 gauge?

Ans. (1) Perhaps we do not fully understand your question; the more usual designation is coal-oil naphtha, and the coal-tar is the final residue after the removal of the oils. The naphthas form quite a series of volatile and inflammable liquids, of which gasoline is one. A person may ask for gasoline, but the Standard Oil Co. sells him naphtha. (2) American Hard Rubber Co., New York City. (3) This is not much used except in the manufacture of submarine cables. Perhaps you could get some from Eimer & Amend, New York City. (4) The B.W.G. No. 14 is .083″.

Series Motor

286. A. D. S., Option, Pa., asks (1) What regulating devices are used for series-wound motors on constant current circuits? (2) Can a motor be overcompounded like a generator to give uniform speed under varying loads? (3) What causes the counter electromotive force in a motor?

Ans. (1) A governor operating on the centrifugal principle, that either varies the number of field turns or the position of the brushes. See page 224, second column of February issue. (2) Yes, this is Sprague's original scheme, but not now used, as being unnecessary. See page 225 of same paper. (3) By the motion of the conductors in the magnetic field, if such motion produces electromotive force in the case of a generator, how can its production be avoided in the case of a motor? See page 198 of the January issue.

Solenoid

287. J. A. H., Dallas, Tex., has been reading answer No. 251 in the June issue and asks for further information as to who Van DePoele was, and how the defects of his drill can be remedied?

Ans. Van DePoele was a builder of arc dynamos and lamps in Chicago, in the early '80's, but soon devoted his attention to electric railroading; his first equipments consisted in having a motor on the front platform, connected with the axles by means of sprocket chains. Current was delivered to motor through a contact wheel running *under* rather than on top the wire. The first commercial installation of this system was in Birmingham, Ala., but inadequate methods of supporting the trolley wire led to its removal. The Thomson-Houston Electric Co., of Lynn, Mass., bought the patents, and waged a vigorous warfare on infringers. Van DePoele himself moved to Lynn, and after considerably improving various details of the railway equipment, began experimenting with the solenoid percussion drill. He died in about 1892. As for the defects of the solenoid principle, they were clearly stated in the June issue; although laminated or slotted metal be used, the long path of the lines of force through air is not thereby reduced. Prof. E. Thomson somewhat improved the scheme. See patent 520,810.

Alcohol

288. L. M. C., Edgewater, Colo., asks (1) What steps to take to secure a position as government inspector of denatured alcohol in his

district? (2) What success has been reached in using alcohol in present forms of gasoline engines? (3) What are the addresses of some firms manufacturing distilling machinery?

Ans. (1) You might address the Secretary of the Interior, at Washington, or better, the congressman from your district; although such positions are in the province of the Civil Service Commission, he would be able to assist you in communicating with the proper official. (2) As nearly as we can find out, special designs of engines are necessary, and not very gratifying success has been attained either in this country or in Europe. The Department of Mechanical Engineering in Columbia University, New York, has made some exhaustive tests. (3) Our lists do not show any.

Wattmeter — Dynamometer

289. I. P. C., Tampa, Fla., asks (1) What is a wattmeter? (2) If a current of 10 amperes produces a deflection of 22 degrees in a Siemens' dynamometer, what is the "constant," and what current would 36 degrees represent?

Ans. (1) We do not know whether you mean merely an indicating wattmeter, or one of the recording type; in the former, there is the attempt at rotation, as in a voltmeter or ammeter, but the motion is opposed by a spring or weight; in the latter, rotation is permitted, and a train of wheels actuated. A wattmeter consists essentially of two stationary coils of relatively coarse wire through which the main current passes; also a movable coil of fine wire, and in addition an adjusted external resistance, for calibration, the terminals being attached across the line, so that through it a shunt current will pass proportional to the voltage. The total torque will then be proportional to the product of the two currents, or to the watts. (2) Current = constant × square root of deflection, or angle through which the pointer must be turned to restore coil to the zero position; performing these operations, the constant is found to be 2.13. The square root of 36 is 6; 6 × 2.13 = 12.78, the required current.

Blasting Dynamos

290. C. H. G., San Rafael, New Mexico, asks if a telephone generator can be changed so as to allow its use in exploding a number of fuses simultaneously?

Ans. To be effective, the various fuses must be connected in parallel, and a dynamo of considerable ampere capacity be used; as the distance to some of the charges may be a few hundred feet, the machine should have a fair voltage. The telephone generator would be considerably too small. A suitable generator would have an electromagnetic field. The 2-light machine described in the Bub. Pub. Co.'s. 10c pamphlet, "How to Make a Dynamo," would be about right for this purpose.

Antenna

291. A. M., Woodside, L. I., asks (1) If the simple wireless receiver described in the Feb. paper will catch signals from passing steamers? (2) Will a good insulated wire do for an antenna, and what should be placed at the upper end? (3) How long will it take to charge a storage battery having one positive and two negatives, 8″ × 8″, from four gravity cells?

Ans. (1) Yes. (2) Insulation on the wire will do no harm or good, but the upper end must be insulated by glass or porcelain from its support. (3) About 200 hours.

Resistances in Parallel

292. J. L., Chelsea, Mass., asks what is the joint resistance of three wires in parallel, each 1,000 ft. long and of 25, 35 and 45 mils diameter, the resistance of the 25 mil wire being 391.8 ohms per 1,000 ft.?

Ans. The cross-section of wires in circular mils is found by squaring the diameter in mils; these squares will then be 625, 1,225, and 2,025; their sum 3,875. The combined resistance will be $^{625}/_{3875}$ of 391.8, or 63.2 ohms.

Lightning Arresters

293. G. W. D., Deer Lodge, Mont., asks if there is any more danger from lightning when the arrester is placed inside a building than on the outside?

Ans. Outside arresters are usually placed on poles, or in case of power transmissions, in separate houses along with the transformers. Those inside the house are merely subsidiary, and are not considered at all dangerous to property or person.

Renewed Lamps

294. C. B. B., Stockport, N. Y., asks (1) What process is used in renewing incandescent lamps? (2) Where are wireless telegraph instruments protected from lightning?

Ans. (1) By manual operations; the tip is removed, and through the small hole a new filament is inserted and stuck in place with the aid of rather slender tweezers. A new tube is then fused on and the lamp re-exhausted. (2) They are not protected, except that during a storm the apparatus is usually inoperative.

Home Made Battery

295. J. W. P., Kennett Sq., Pa., asks if a battery can be made by using half a dozen dry cell carbons thrust through a wooden cover, surrounding an ordinary zinc pencil? Sal ammoniac solution would be used.

Ans. For such work as intermittent operation of bells, the battery will suffice, but the absence of any dioxide of manganese in contact with the carbons will allow quick polarization, if you attempt to prolong the current. Avoid the distressing action of the creeping salts by covering the upper ends of carbons and the wooden disc with a mixture of resin and beeswax.

Motorman or Engineer

296. N. E. G., Cresco, Mich., asks how a person could learn to be a motorman on a electric car or to run a gasolene launch? Would a course of instruction in a correspondence school be helpful?

Ans. Get what information you can from books, and meanwhile secure a position in a machine shop, even though it be no better than washing windows. Familiarity with machine tools and methods of doing work is all-important. To become a motorman you must seek the acquaintance of the foreman of repair shops or car houses, and make persistent application for a position. For the gasolene launch, you ought merely to seek a position as machinist with a firm that builds them. Then in due season, with that concern or some other, ask for the desired class of work.

Motor Switch

297. R. D. C., Pittsburg, Pa., asks (1) How best, in an emergency, to shut the current off a motor from a distant point? (2) What is meant by a "bipolar" dynamo? (3) What is an easy way to test out a short circuit in an armature?

Ans. As your sketch shows an automatic no voltage release starting rheostat (like that described in Chapter VIII. of the electrical engineering series), you can readily make an attachment to admit stopping the motor from any desired location. Merely solder the ends of a piece of lamp cord to the ends of the winding of the release magnet, run the cord where wanted and attach to it an ordinary push-button. The act of pressing the button will short-circuit the winding, remove the magnetism, and allow the rheostat arm to fly to the "off" position. With your particular connections, this movement breaks field as well as armature circuit; if the latter only is opened, care must then be taken to open the main switch, or current will be wasted and the field coils unduly heated. (2) One with only two poles,—say the typical Edison or Thomson-Houston style. (3) What may be easy for one person may be unavailable for another. If you have means of driving the armature at full speed, with the field magnets separately excited, you can make the best test. Remove the brushes, and start the armature revolving freely; then excite the field magnet, using lamps or a rheostat to allow a gradual increase of field current. If appreciably no more power is required to drive armature under these last conditions than when no magnetism was produced, the armature has no ground or short circuits. If considerable expenditure of power is needed, heat and smoke will soon be manifest, and a few moment's run will suffice to locate the fault.

110-volt Motor

298. F. E. B., Mendota, Wis., asks (1) What winding to put on a small armature with 12 ¼″ × ⅜″ slots,—a 6-segment commutator, and single-coil cast iron field magnet being used,—to allow for running on a 110-volt direct current? Lamps can be used for resistance. (2) Will an alternating current fan motor wound for 110 volts run on a 110-volt direct current circuit?

Ans. (1) As we do not know the length of the armature nor size of field magnet, we have no data upon which to figure. By using a 12-segment commutator, and putting on the wire in the established manner, it will be possible to wind for 110 volts without the wasteful necessity of using external resistance. Possibly No. 26 wire on armature and No. 23 on fields would suffice. (2) No.

Meter Reading

299. E. T. F., Renovo, Pa., asks how to take the reading of an ordinary Thomson recording watt-hour meter?

Ans. It is true that some care must be used for errors are easily made. First it must be borne in mind that the figures marked under or over each dial (1,000, 10,000, etc.), refer to a *complete* revolution of the hand of that dial; therefore, each division on the dial to the extreme right indicates not one, two, three, or four thousands of units, but one, two, three, or four hundreds of units. That is, the dial does not read thousands, but one complete turn means one thousand. A complete revolution of the first hand then will be 1,000, and the second dial will show one division. A hand to be read as having completed a division must be confirmed by the hand before it (to the right):

unless the hand before it has reached or passed the zero, or in other words, completed a revolution, the other has not completed the division on which it may appear to rest. For this reason it will be found easier and quicker to read a dial from right to left. Attention must be paid to the "constant," i.e. the number by which the meter reading must be multiplied in order to give the correct watts. Often, however, this constant is simply 1. If it is desired to know the instantaneous watts, say for checking accuracy of a meter, the revolutions of the copper disc should be counted for three or five minutes, then the watts $= 60 \times$ constant $\times$ revolutions $\div$ time in minutes.

Fan Motor

300. J. A. O., Chicago, Ill., wishes to turn a 12" "Paragon" fan motor into a generator. Armature is wound with No. 21 wire, field with No. 22. What would the output be?

Ans. Direct current fan motors are ordinarily series wound, but in your case the field wire seems rather small. You can somewhat remedy this high resistance by putting the two coils in parallel rather than in series with each other. To make a series wound dynamo generate a current, you must drive it in the opposite direction from that in which it runs as a motor. A current of about 2 amperes will be allowable, voltage dependent upon the speed at which you drive it.

Wimshurst Machine

301. A. B. C., ——— asks (1) If a Wimshurst machine can be used to supply current for operating a wireless telegraph outfit? (2) What is the construction of a telegraph receiver for wireless messages? (3) Is it possible to send 10 amperes at a pressure of 2 ½ volts through a 50-ampere-hour storage battery?

Ans. (1) No, it does not supply enough current. (2) One was described in the February issue. (3) Yes.

Alternating Current to Direct

302. I. A. S., Ft. William, Ont., asks if it is possible to change alternating currents to direct in the case of a long distance transmission, by the use of commutators in sub-stations?

Ans. Yes, this is regularly done, but the device consists of more than a mere commutator. Wires must be connected to the various segments, and these wires must cut a magnetic field. The complete device is technically denoted as a "rotary converter." Alternating currents of proper voltage, phase relations, and frequency are delivered to the collector rings that connect to the same winding as does the commutator. From one end, the machine looks like an ordinary direct current generator, from the other end like an alternator with revolving armature.

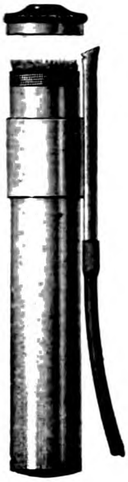
Field Rheostat

303. M. H., Denmark, S.C., asks (1) How to connect a rheostat in the field of a shunt dynamo? (2) A small dynamo, intended for 50 volts and 4 amperes, fails to generate. What is the reason?

Ans. The diagrams accompanying Chapter XII. of the Electrical Engineering series illustrate this point. Also a practical way, in case of a 2-pole dynamo, is to lead a wire from each brush to a field end, and connect the other field ends to the rheostat. Just which end of the spool winding to use for the brush connection will depend upon the type of field magnet and method of winding; but the procedure is to try it one way, and if this does not work, try the other. Make this trial connection with one spool only,— the other spool is sure to fit one condition or the other. (2) A very reliable method, if you have current available, is to try the machine as a motor. If it will not yield to this trial, it is of no use to try to make it generate. Something must be fundamentally wrong in the winding or connections. If machine will run as a motor, set brushes in position for lowest speed and least sparking. Then in case of a shunt dynamo, drive it at a somewhat higher speed, in the same direction. If this trial does not avail, write us again, stating just what design you have been following.

304. D. E. F., ——— asks (1) If there is any way to renew dry batteries? (2) Can a motor be made from a 4-bar telephone generator without rewinding? (3) How many volts are needed to melt a small needle?

Ans. (1) Try covering outer ends of carbon with hot paraffin, and then let the cells soak for a few days in a strong solution of sal ammoniac. If there are any holes in the zinc receptacle, it hardly pays to try to renew the filling. (2) Not if you wish to get good running conditions. (3) Volts do not melt anything. It is current that does the heating, and current is measured in amperes; volts simply indicate the pressure necessary to drive the current. It is like the case of a water wheel; water makes the wheel go, but pressure is needed to drive the water. We can see water, but we cannot see the pressure. Though amperes cannot actually be seen, their presence would be testified by the heat. Electrical pressure, in volts, is something abstract, like water pressure, and cannot be clothed in any physical form.



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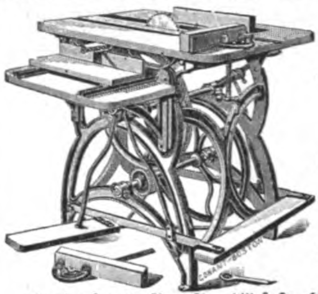

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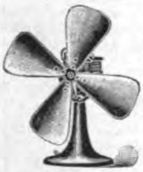

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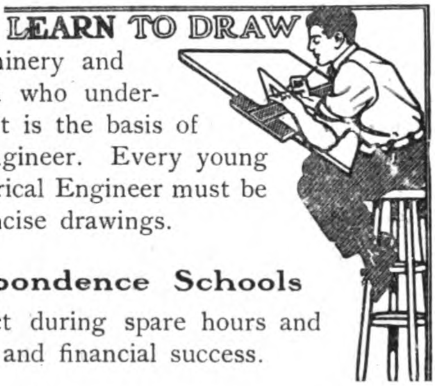

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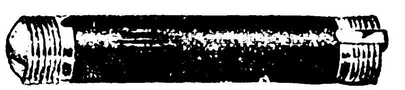

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