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ELECTRICAL ENGINEERING—Chapter XIV

Alternating Current Generators

A. E. WATSON

A dynamo for generating alternating currents is usually distinguishable from one of the direct current sort by the absence of a commutator, and by its numerous field-magnet poles. Still, some instances will be considered in proper place, in which there may actually be a commutator or only few poles. A feature in which there is little danger of confusion with direct current apparatus is the now common practice of having the field-magnet of the alternator the revolving member. It can easily be seen that the other class could with only great difficulty in mechanical construction, and with no mitigating advantages, provide for a revolving field-magnet rather than armature. Commutation is effected by means of stationary brushes that momentarily connect with coils passing through the "neutral" point; if the armature and commutator were stationary, the brush holders and their fastening would have to revolve, yet with provision for shifting the position of brushes to prevent sparking, also with rings and sliding contacts for delivering the current to the exterior load.

While many of the early alternators imitated the direct current style of construction, and had revolving armatures, some of the very earliest, notably those built by Gramme for operating Jablochkoff candles, and later those by Mordey, had revolving fields. It is worth noting that, except in detail, Gramme's original construction is not essentially different from the present approved design.

While it is quite possible to use an ordinary ring or drum wound armature for alternating currents, it is not customary, except in case of "rotary-converters," to adopt it. The ring armature has too much self induction to allow good regulating qualities for the usual constant potential work, and the simple drum would not allow for generating a sufficiently high electromotive force. The rotary converter is a relatively low potential machine. The sphere of alternating currents is in long distance transmission, and for securing the desired high potentials a large number of conductors must be connected in series. For a simple case, the various groups of conductors must be acted upon by their neighboring poles all at the same instant. To accomplish this a distinctive type of winding has been devised, often called "pole" type A description of an actual machine will make the matter clearer. Figure 57 represents the construction common in about 1888. This is a Thomson-Houston machine of 35 kilowatts capacity,—closely copied from the earlier Westinghouse pattern. It has a smooth-core armature acted upon by a field-magnet of 10 poles; a direct current machine of 3 k.w. capacity, for energizing, or "exciting," these poles, therefore commonly called an "exciter," is shown at the right hand, driven by a small belt. Sometimes the exciters are directly connected on the main shaft, and in other cases they are entirely independent machines. Independence is usually desirable, for if by variation of speed, there should be some fluctuation of potential, the change will not then be exaggerated by the variations of the exciter.

The armature shown is about 18″ in diameter, and 10″ in length under the poles. Ten strips of fibre, 10″ long and ⅛″ thick, are pinned length-wise to the core, equidistant, and serve to locate and drive the electrical conductors. These consist of single layers of rectangular wire, wound like flat elongated shuttles, of perhaps 20 turns each. Being so thin and flat, they were commonly designated as "pan-cake" coils. They were connected in series, first two inside ends, then two outside ends, etc., and except for the interposition of a commutator for assistance in regulating the potential, the final ends were led to the "collector rings," shown between the bearing and the armature. The commutator is shown just outside the bearing, with adjustable brushes, as is usual for direct current machines. The function and construction of this adjunct is, however, a little peculiar, and well worth examining. Though apparently of ten segments, to equal the number of poles, there are really but two segments; two castings of five prongs each are slid together, much as the fingers and thumbs of the two hands might be placed, and one terminal of the armature winding is led through a hole in the shaft to one of these castings, while another wire passes from the other casting to one of the rings. The other armature terminal connects directly with the second ring. Commutation is effected in the same manner as with an ordinary two-segment commutator, as used with a Siemen's shuttle armature, but with the only difference that the two segments are subdivided and interspersed to accommodate the increased number of field poles. Since half the number of poles is an odd number, diametrically opposite points will be proper places for the brushes, as is the case with a bipolar direct current dynamo. Several other positions would, however, be equally allowable, as long as the two brushes touched the two different castings. Had the field an even number of pairs of poles, say eight poles, opposite points of the commutator would be on the same casting, so some unsymmetrical location of brushes would be necessary. The regular machines of this type had 10, 14, and 22 poles, therefore in each case the brushes were placed opposite.

Two different windings are on the field cores, the greater part supplied with current from the exciter; the other part is fed with the temporarily rectified current from the main armature. It is recognized that this gives a sort of compound winding, the separate excitation corresponding to the shunt, and the self excitation to the series portion. At no load, there will be just enough magnetization to give the normal voltage; as the load increases there will be a somewhat increased strength of field, to allow for various inevitable losses. In order to have a term to cover this particular style of excitation, Prof. Thomson denoted it as "composite." With incandescent lamp loads, the scheme was very successful and popular with station managers. Since the only difference of potential between the two segments was that due to the ohmic resistance of the series portion of the field winding, — say 5 or 10 volts, while between the rings there was 1000 or 2000 volts,— there was an almost entire absence of sparking. When combined with motor loads, however, which with every change of load gave a different angle of lag, and required a different position of brushes, the scheme had to be abandoned, and reliance for regulation placed upon better design, with simple manipulation of the strength of the exciter field.

The standard speed for this size of dynamo was 1500 revolutions per minute. From the definition that the number of "cycles" equals the number of pairs of poles multiplied by the number of revolutions per *second*, it is found that the "frequency" (cycles) is 125. The Westinghouse Co. drove a similar machine at a normal speed of 1600 revolutions, resulting in a frequency of 133. Both these figures are known as the old high frequency.

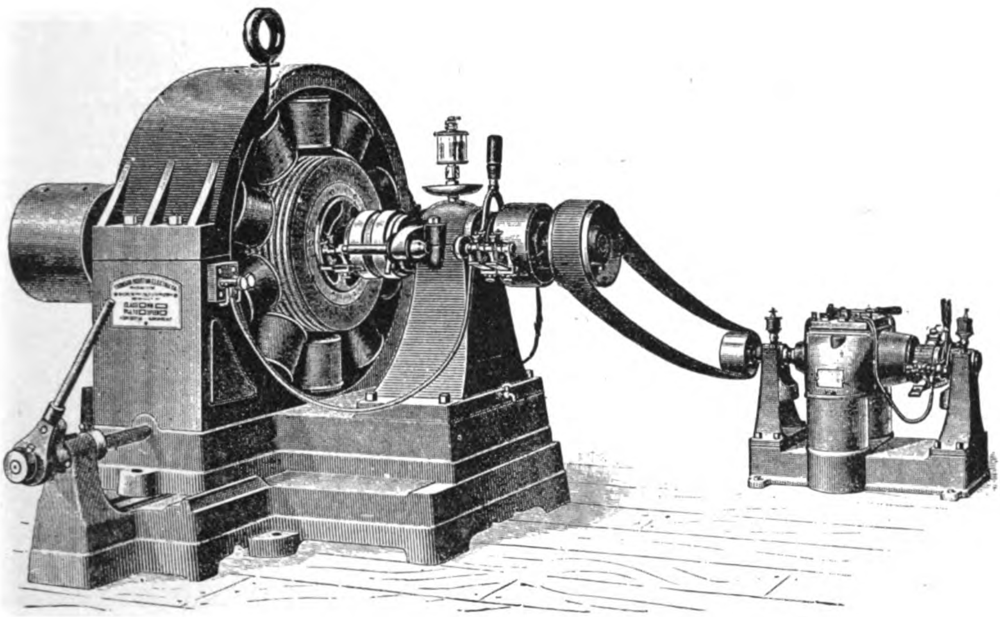


FIG. 57
Alternating Current Generator and its Exciter. Type of 1888

With the introduction of "iron-clad," or toothed armatures, with T-shaped teeth, the output of the 35 k.w. machine was increased to 60 k.w., but with such a rise of temperature in the solid cast iron of the field-magnets that laminated cores became imperative.

By 1890 the means had been discovered of satisfactorily operating motors on alternating currents, and lower frequencies than usual for lighting purposes were desirable. Added to this requirement was the desire to get the speed low enough to admit direct coupling of armature to steam engine. Such a frequency was sought as would allow for the operation of all classes of service, —incandescent and arc lamps and motors. Arc lamps do not work well at less than 40 cycles, so to be safely removed from that limit 60 was selected as a good figure. In Europe, however, 50 was adopted, and American engineers are now inclined to admit that that is rather the better frequency. The Westinghouse and Thomson-Houston Companies each built a 375 k.w. 80-pole, 90-rev. dynamo for an electric lighting company in Providence, R.I., at this time, which were the first of their kind. In recent years they have been fitted with new armatures of the three-phase sort, with an increase of rating to 525 k.w.

For ordinary electric lighting, simple armature windings with a single circuit, and denoted as "single-phase," are sufficient. Motors, however, especially those of considerable size, require an orderly succession of currents, such as to give a progression to the magnetic flux, in the direction of rotation, and at no time to leave the machine without some working force. If, in addition to the winding required for a single-phase circuit, other sets of similar coils were placed midway, the terminals connected to two additional rings, making four rings in all, first one circuit would be energized, then the other, the current dying out in one while it was rising in the other, and when one was generating its maximum the other would be at its zero value. The analogy of a two-crank engine,—a locomotive, for instance, makes the idea clear from a mechanical point of view. If three sets of coils were employed, so that when one set was directly under the poles, and therefore in the most active position, another had just

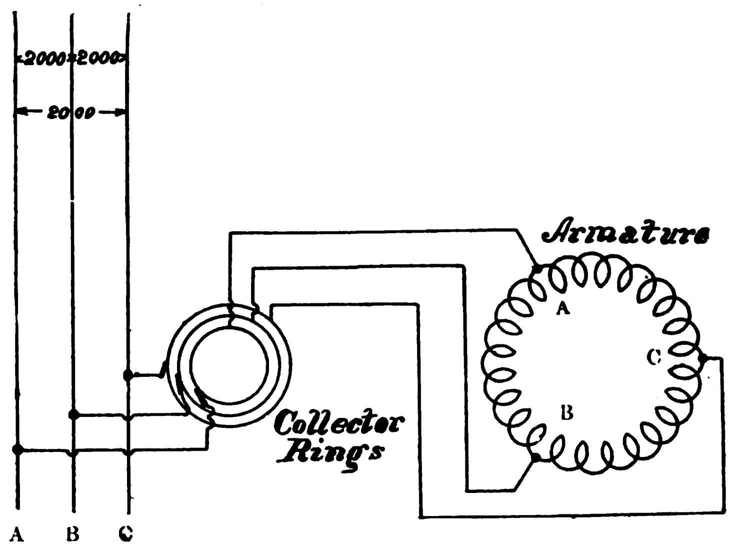


Fig. 58

Connections for Three-Phase "Delta" (Mesh) Revolving Armature

gone by that position, while the third was approaching it, there would result the "three-phase" circuit. The three sets of coils would give six ends, and apparently require as many collector rings, but by joining three of the ends at once together, or by letting the end of one set be the beginning of the next, only three rings are actually needed. The three-cylinder engine,— say of the marine type,— suggests how the maximum and zero values of the different current waves follow each other.

Ordinary direct-current dynamos can be made into alternators of any desired number of phases, by substituting rings for the commutators, connected to appropriate points of the winding, or temporarily, by slipping rings over the commutators. A thin wooden shell, or sheet of fibre or mica, could first be placed on; then for a single-phase two rings could be used; and by means of a headless set screw in each, connection could easily be made in case of a two-pole field with the two segments directly opposite. If enough of the commutator was still exposed, the machine could be self exciting, and even for the delivery of direct current in addition to the alternating. Of course, the sum of these two currents should not exceed the regular ampere capacity of the winding. By use of three rings connected, respectively, to three equidistant segments, three-phase currents would be available, while four rings,— the pair belonging to each circuit being connected to opposite segments, but only one quarter of the winding intervening between the two circuits,— will allow for two-phase.

Reference to Figs. 58 and 59 will make the idea entirely clear. Ring armatures of the revolving type, are here diagrammatically represented, with their collector rings and brushes. Taps are led out at three equidistant points in one and at four points in the other, and connect with the exterior circuits of three or four wires. No confusion must be made between the genuine three-phase wiring and the familiar Edison "three-wire" system; it is true that each uses three wires, but in the former all three wires are supposed to carry equal currents, therefore are of the same size and equally important; in the latter it is aimed to have the middle one "neutral," or idle, and in case of a balanced load it carries no current at all, and is often of smaller size than the other two. Again, in case of the three-wire system, there is twice the voltage between the outer wires that there is between either of these and the neutral; with the three-phase there is the same voltage between any pairs of wires. This condition is emphasized in the diagram, where it is

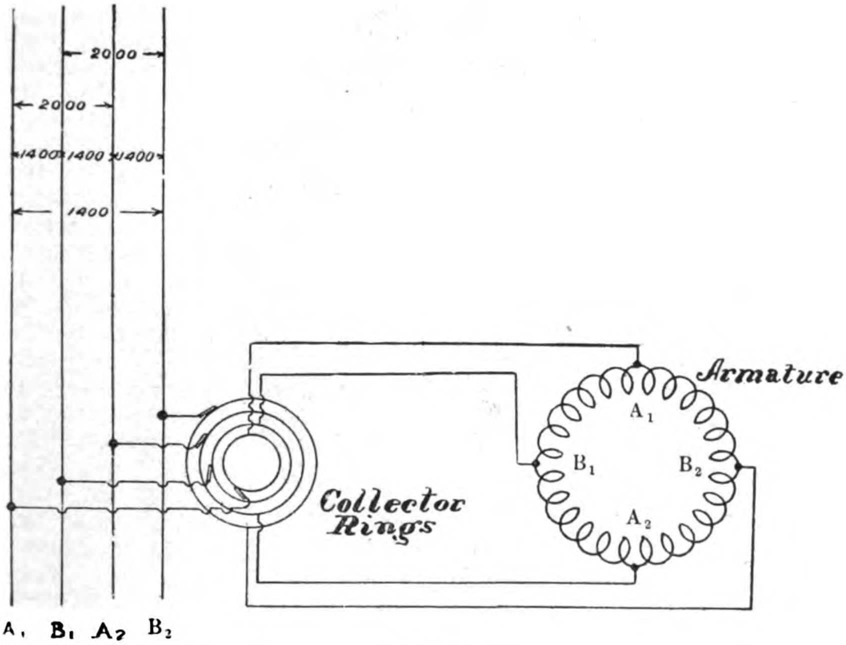


FIG. 59

Connections for Two-Phase Closed-Circuit (Mesh) Revolving Armature

represented that there is a difference of potential of 2000 volts in all three places. With the two-phase winding, opposite points A and A_1, belong to one phase, while B and B_1 serve for the other. Since diameters drawn through these points would be at right angles to each other, the two circuits are sometimes described as being in "quadrature" with each other, and frequently called "quarter-phase," as well as two-phase.

If three straight lines should be drawn to connect the points A, B, and C of Fig. 58, they would form an equilateral triangle, or the Greek letter "delta"; this designation is a very convenient one, and this style of winding, with drum rather than ring armatures, and multipolar field-magnets, is used for almost all generators and motors not exceeding 2000 volts in working potential. It is imperative for rotary converters, or there would not exist the opportunity to connect the same winding to the many segments of the commutator.

The two-phase winding shown in Fig. 59 is also an interconnected, or "mesh" arrangement, hence, if desired, current could be taken from points adjacent rather than opposite to each other. If there is a difference of 2000 volts between A and A_1, there will be about 1400 volts between A and B. This can readily be proved by drawing the diameters, and connecting the points A and B with a straight line; this becomes the diagonal of a square, in length equal to fourteen-twentieths of the diameter. Geometrical and not arithmetical solutions must be given to all combinations of alternating electromotive force.

For high potential three-phase generators it is customary to have one connection in common between the coils and to lead the other three ends to the outgoing terminals. This is graphically designated as the "Y" winding. A Thomson-Houston arc dynamo can be readily changed into an alternator of this sort by substituting three rings for the three regular commutator segments. Of course the field magnet would then require separate excitation. The common connection is really a neutral point, and a fourth ring could be connected to it if desired. This is a method sometimes adopted in central station operation,— *i.e.* to operate motors from the three main wires, but to tap single-phase transformers between any one of these

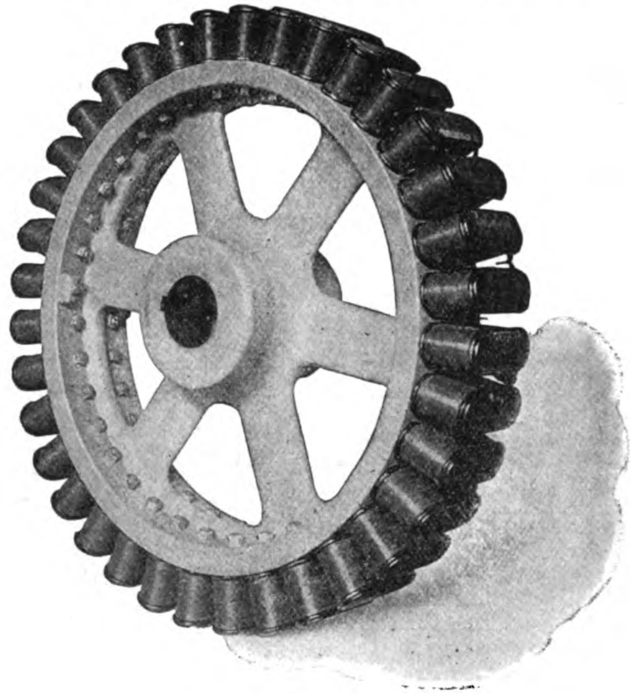


FIG. 60
Revolving Field-Magnet (40 Poles) for Alternating Current Generator

and the neutral. For assisting in protection from lightning, this neutral can be grounded, without danger of throwing the system out of balance. To see such a machine, one would easily mistake it for a "two-phaser," and a careful scrutiny of the switchboard arrangements might be needed to reveal the real conditions.

Conversely, a two-phase machine can get along with only three wires. In this case, the two circuits would have one wire in common, and this ought to be of twice the section of the others. The two phases are, however, preferably kept separate, and such joint use of a wire reserved for cases of breakdown.

With the adoption of increasingly higher voltage, it was deemed imperative to provide for personal safety, as well as to improve the general reliability of the apparatus, by eliminating the alternating current from the collector rings. By letting the armature be the exterior member, and stationary, larger slots and thicker insulation could be used; larger spaces for the circulation of air were possible, and the connections could be led from convenient points in the winding, inside the frame of machine, quite out of sight and reach, to the switching devices. Being free from the jarring and vibration common to rotating bodies, the conditions were made favorable for preservation of the insulation. The field-magnet is now usually made to consist of laminated poles mounted on the rim of a cast iron or steel wheel, often of sufficient weight to serve also as a balance wheel. The winding, instead of being of ordinary round insulated wire, is made of bare copper ribbon, say $1/32''$ to $1/16''$ in thickness, and $1''$ to $1\frac{1}{4}''$ in width, wound *on edge*. Special tools involving considerable ingenuity have been devised for this operation, and have contributed in no small degree to the success of this type of machine. Of course the iron poles are properly insulated with paper and mica, these flat coils slipped in place, their separate convolutions now insulated with paper, but with the exception of the paint, the outer edges are left quite bare. When revolving, the field-magnet stirs considerable air, resulting in generous cooling of these outer edges, but the cooling effect is readily communicated to the inner portions of the conductor. It is seen that with ordinary wire, the act of cooling the outer layer would have much less effect on the bottom layers, separated by considerable accumulation of insulation. Practically, the result is that about twice as much current can be sent through ribbon-wound coils as through those of the other sort. Two insulated rings are needed on the shaft of the machine, to serve as terminals for this winding, upon which brushes rest, and conduct the *direct* current for the excitation. It is seen that however high may be the potential for which the armature may be wound, the field may still be energized from any desired low potential source. 110 is the most common voltage used,—a potential regarded by dynamo tenders as a plaything. Copper rings and brushes are to be expected in such places, but cast iron rings and carbon brushes make a surprisingly durable combination.

Fig. 60 shows a 36-pole field-magnet of the particular construction which is standard with the General Electric Co.

It is rather difficult to give an adequate idea of the exact armature winding for large alternators. The student must needs have reference to complete diagrams, and supplement such inquiry with investigation of the machines themselves. The windings were really first used on motors, then recognized as eminently fitted for generators also. Under the topic of alternating current motors to be considered in the next two chapters further opportunity will be afforded to give insight into these matters. In general, it may now be said that the coils can follow either of two general schemes, one closely imitating the formed-coil winding used with direct current drum armatures, and called the "distributed" or "Polyphase" type, and the other,—quite distinctive to its class,—made of rectangular coils that surround or pass through one another. A representation of this latter arrangement is given in Fig 61. In order to approach the excellence of wave-form given by the other type of winding, the several coils are made double, or with "two coils per pole per phase." The winding is for three phases, and from the appearance of the ends is often called the "chain" type. Proper spacing of the poles to fit this winding is given by the figures 1, 2, 3, and 4 Inner and outer

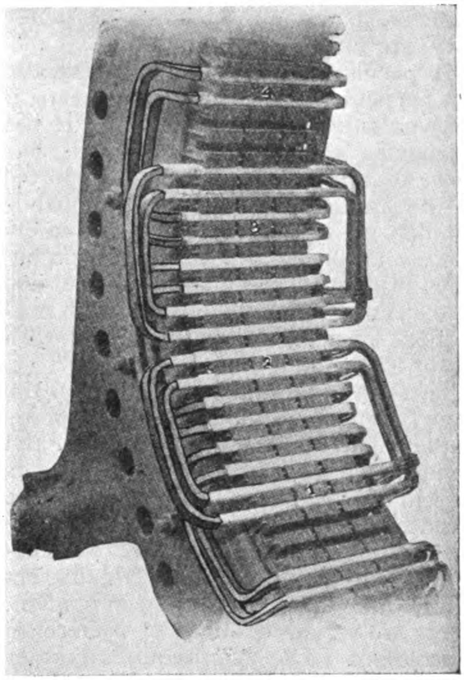


FIG. 61
Stationary Armature Winding for 3-Phase Generator

coils of each pair are wound in the same direction, as if one was a mere continuation of the other, but the coils 1-2 are connected in the opposite direction with the pair 3-4, the next ones of the same phase. The same scheme would continue around the entire circle, embracing one-third of all the coils, while the rest would be connected in two other but similar circuits. Finally, for ordinary potentials, the six terminals might be connected in a delta arrangement, or for higher potentials, in the Y manner. The same coils connected as a Y will give a terminal voltage 1.73 times as much as the delta. The latter has, however, 1.73 times the ampere capacity as the other, thus the capacity in watts is properly the same for both types. By reason of the relatively fewer slots, greater thickness of insulation can be allowed than with the distributed type, and this, together with the freedom from actual contact of the various coils, makes the possibility of winding armatures of 6000, 13,000 and even 30,000 volts. In such cases, the insulation may be of mica ⅜″ in thickness. By winding the generators directly for such potentials, the first cost and continual losses in transformers, that would otherwise be necessary, are saved.

A peculiar construction of alternator, not particularly favored by engineers, is known as the "inductor" type. It has no moving wire at all, the field coils, like those of the armature, being supported on the stationary part of machine, while chunks of laminated iron alternately make and break the magnetic circuit. The principal defect seems to be due to excessive magnetic leakage, with consequent poor regulation, especially with motor loads.

Two-phase armatures are made in the same manner as shown in Fig. 60, by employing only two sets of coils, and having such a number of slots that one set will overhang or embrace one-half the breadth of the other. As to the relative qualifications of the two-phase as compared with the three-phase circuits, engineers are somewhat divided in opinion. There are various grounds of preference or economy. The latter requires a rather more careful balancing of "feeders" than the other, so sometimes the two-phase is selected for purposes of local distribution. The three-phase transmission, however, requires only three-quarters as much weight of copper as the other, hence for long distance transmission, with the added gain in saving one line of insulators, there is seen the reason for the general adoption of this system. For the same weight of materials, the two-phase generator has the advantage, for a slightly greater output can be obtained. Many instances can be found, notably in the case of the Niagara installation, where two-phase generators are used, with transformers that, while stepping up the potential, also change the currents to three phases. Economy of both generation and transmission is thereby secured

Rejuvenating Dry Batteries

When a set of dry batteries that has been used in the ignition system of a car has reached the point where it fails to give off an amount of current sufficient to operate the motor without missed explosions, the cells may in many cases be rejuvenated and used for some little time. To do this holes should be made, preferably with some round, sharp-pointed instrument not more than an eighth of an inch in diameter, through the sealing compound which covers the top and down into the filling mixture between the central carbon pencil and the lining of the zinc shell. As many of these holes as possible, without cutting up the sealing compound too much, should be made and into them should be poured as much water as will be readily absorbed by the cell, or in place of water, muriatic acid. Cells which before the treatment would register only three amperes on short circuit have been known to have been brought up to twenty amperes by means of it. The addition of water alone will usually enable the cell to give off about ten amperes, and good cider vinegar, which may also be used, fifteen. The sealing compound at the top of the cell is usually very hard and brittle, and will break if attacked in the manner indicated above. It would therefore be well to heat slightly the instrument used to make the holes before the operation, so that there will be no danger of the compound's cracking. The holes should be made near the centre of the space between the carbon and zinc elements, and care should be taken in inserting the sharp instrument to see that it goes in parallel with the carbon pencil, and not obliquely, as, in the latter case, it may puncture the absorbent lining of the zinc shell and enable some of the carbon filling compound to come in contact with this shell and thereby cause a short circuit which will destroy the cell rapidly. When the water or acid has been added the holes may be sealed up by applying a slightly heated piece of metal to the sealing compound around them.

Long life is not the only attribute of a good lamp, and too many people make the mistake of believing that one lamp is more economical than another merely because it burns longer. At least two other factors must be considered — maintenance of candle power and cost of the current consumed. The lamp which combines with long life, a uniform candle power and minimum power consumption is the best lamp and each of these factors should be reckoned with in determining which is the best and most economical lamp to use.

The Amateur's Workshop

An Experimental Wireless Telegraph Outfit — (Continued)

T. E. O'DONNELL

After the filings in the tube of the coherer have once been rendered a conductor by the influence of the oscillatory electrical wave, the current from the battery will of course continue to pass through them unless some means is adopted to restore the particles in the coherer to their original non-conducting state. This is done by decohering the filings, that is, shaking them up or detaching them from each other. The device used is called a decoherer.

A very simple way of accomplishing this is to have a little rod and hammer arranged in such a manner that when the sounder works it taps against the glass tube of the coherer and effects the decoherence of the filings. If an electric bell is used in place of the sounder, this can be done very conveniently by mounting the bell upon the same base with the coherer; fastening it down firmly and adjusting it so that the hammer of the bell will just strike the tube lightly when it swings back from its stroke against the bell gong. That is, the bell can be made to serve a double purpose, that of giving the signal and at the same time acting as a decoherer.

For this purpose procure a common form of electric bell with a 2½″ gong, and to the hammer attach a piece of ⅛″ brass rod 1″ long. This may be done by drilling a ⅛″ hole in the side of the knob or hammer of the bell, inserting one end and soldering it firmly. The bell should then be thoroughly tested to see if it will ring freely when fastened down upon a flat base. The position of the short brass rod when fastened to the bell can be seen in Fig. 3.

On account of the position the bell occupies in relation to the coherer, the use of this form of receiver is limited. A better form, and more efficient, would consist of a regular 5-ohm telegraph sounder in place of the bell and the use of a separate decoherer.

A decoherer can be made very conveniently from a pair of magnets removed from an electric bell, or by using them as they are on the bell, by removing the gong and making the hammer do the tapping. The magnets of the decoherer should be wound to 5 ohms resistance, the same as the sounder. The relay used, either in connection with the bell or sounder, should be wound for 100 ohms. This form is generally known as the "pony" relay.

The batteries used in connection with wireless telegraph apparatus should be some form of constant current battery, if the instruments are to be used constantly, especially those used in the primary circuit of the induction coil. However, for ordinary experimental purposes dry cells are the cheapest and by far the most convenient. Three sets of

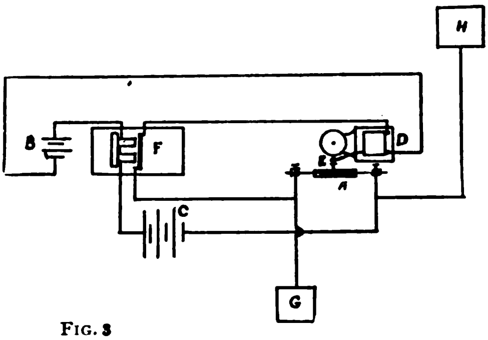


FIG. 3

batteries will be needed to operate the apparatus, one set of five cells for the induction coil, and two sets of three cells each, one for the relay or coherer circuit, and the other for the local or sounder circuit.

The aerial plates used in connection with this set of apparatus should be a piece of thin sheet copper or brass about 18″ square, fastened to the top of a pole or sky rod. This pole should be at least 20 or 25 feet high, if experiments of any consequence are to be made outside of buildings. At the transmitter end, one end of a well insulated wire is soldered to one corner of the plate, run down the pole and connected to one of the oscillators on the coil. The other oscillator is connected to the ground by a similar wire which is soldered to a plate of about ½ the size of the aerial plate; which plate should be buried in the ground to a depth of at least 2 ft., or until moist earth can be had for imbedding it. A water pipe may be conveniently used for the ground circuit. The latter is called the ground plate and the former the aerial plate.

At the receiver end a similar aerial plate is connected by an insulated copper wire with one terminal of the coherer. The other terminal is connected to a ground plate at that end.

All the different parts being provided for, the next step is to assemble the apparatus in working order. Fig. 3 shows the method of connecting up the different parts when a separate decoherer is used, and Fig. 4 that of assembling the parts when an electric bell is used

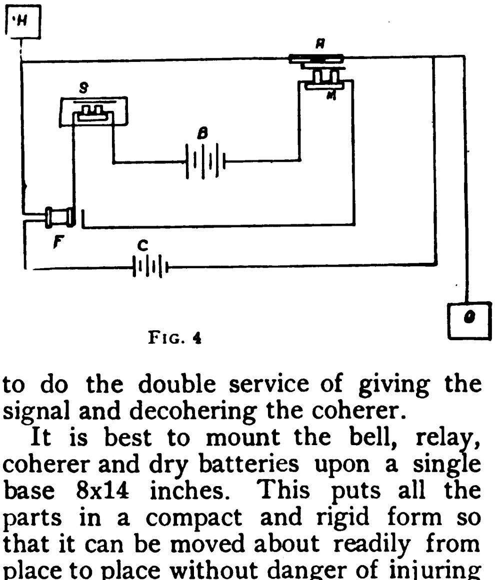


FIG. 4

to do the double service of giving the signal and decohering the coherer.

It is best to mount the bell, relay, coherer and dry batteries upon a single base 8x14 inches. This puts all the parts in a compact and rigid form so that it can be moved about readily from place to place without danger of injuring the adjustments or connections. The general scheme of mounting the separate parts can be seen from the diagrams. Considerable care and patience will be necessary to adjust the receiver, but a little perseverence will meet with success.

Referring to Fig. 3, A is coherer; B the battery to bell through relay contact; C the battery to relay through the coherer; D the bell; E is the decoherer; F is the pony relay; G the ground plate, and H the aerial plate.

In Fig. 4 the bell is replaced by a sounder, S; and the decoherer, by the separate decoherer, M.

Six-Cylinder Motor Engine

Because the trend of motor car design has progressed steadily from the primitive "one-lung" motor to the double opposed, then four and finally six cylinders, some persons believe there will be no end to the multiplication of cylinders and that 8, 12, 16 and 32-cylinder cars loom up in the future. Nothing can be so silly as this conclusion, according to Henry Ford. The reasons are the same that makes six cylinders the ideal in gas engine design purely mechanical; they are many and some of them so intricate as to be difficult of elucidation save to a student of engineering. But some will be plain to every motorist who knows the simplest principle involved in his motor.

With more than six cylinders the exhaust overlaps to such an extent as to cause trouble — it is impossible to clear one exhaust before the next discharges into the manifold. The same is true of the intake. There is an uneven draught in all types of motors save the six, which type, drawing steadily and constantly on the carbureter, permits of adjustment for a uniform mixture at all times. Then in matters of ignition the six-cylinder motor is the limit at which we can obtain the necessary spark advance without overlapping and thereby running into all manner of complications. A single carbureter and single commutator give ideal results with six cylinders. Eight cylinders call for two carbureters and two commutators, a condition that makes synchronousness impossible of attainment. There are other details in which eight or more cylinders call for totally different treatment from that of four or six.

The factor which sets the limit at six, however, is that of balance and the consequent lack of vibration. Strangely enough and yet clearly enough we do not obtain the degree of perfection in any motor of more than six cylinders that we have in that type until we reach the impossible multiple of thirty-six. Nor in any other do we get the even, constant torque, which means constant power at low as well as at high speed. This quality we term flexibility, and in this respect the six-cylinder car has a decided advantage over every other known type of gasoline engine.

Mechanical Drawing

WILLIAM C. TERRY

LETTERING

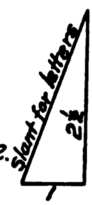
In connection with the study of mechanical drawing it is important to have extended practice in lettering and dimensioning.

a b c d e f g h i j k l m n o p q r

s t u v w x y z 1 2 3 4 5 6 7 8 9 0

A B C D E F G H I J K L M N O P

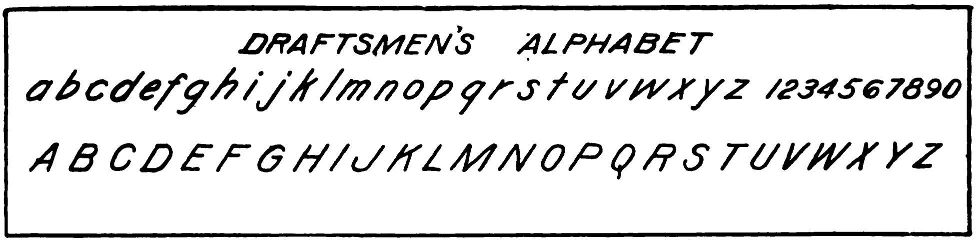
Q R S T U V W X Y Z &



A ball pointed pen was used in inking the above. The arrows indicate the direction of stroke.

The ruling pen may be used for lettering if these instructions are followed: Hold the pen at any angle between 45° and 60° with the paper, with the regulating screw horizontal and the thumb resting against the head of the screw. Render the letters according to the above alphabet. It is best to fill the pen with the common writing pen, or a quill, as wiping is likely to absorb too much ink from between the blades.

The above are free hand letters, and is the form that gives the minimum of time and labor in its construction. When making notes on a drawing with this letter the only guides necessary are two parallel lines drawn lightly in pencil the letters should be sketched lightly in pencil first, and then carefully inked, improving spacing and proportions to satisfy the eye.



FIGURING. Great care should be taken in figuring or dimensioning a mechanical drawing, especially a working drawing. To have a drawing accurately, legibly, and neatly figured is considered by practical men to be the most important part of a working drawing. There should be absolutely no doubt whatever about the character of a number representing a dimension on a drawing. Many mistakes have been made, incurring loss of time, labor and money through a wrong reading of a dimension. Drawings should be so fully dimensioned there will be no need for the pattern-maker or machinist to measure any part of them.

BREAKS. Breaks are used in drawings to represent that a shaft, rod, pipe, etc., is broken off. This is done when there is not enough space on the paper to draw in full length any portion of the mechanism, or when it is undesirable and unnecessary to use the space required for the purpose. These breaks are also used to show the shape of the cross-section and the kind of material of which it is composed. The irregular lines of fracture are made in black ink and are drawn best with the ruling pen held carefully and twisted in the fingers, so as to keep the nibs always parallel with the line of direction of the movement. One of these lines is a shade line throughout; the other, a light line. This adds much to the effect. The rod must always be broken as shown, so that a piece is lost from the central portion and the ends left intact. In this way the total length or over-all dimension may be given, (Fig. 1). A variation is sometimes made in the method of making the break, as shown in Fig. 2. This shows the material, the hatching being done in accordance with our "Standard."

A break for pipe is shown by Fig. 3, and for wood by Fig. 4.

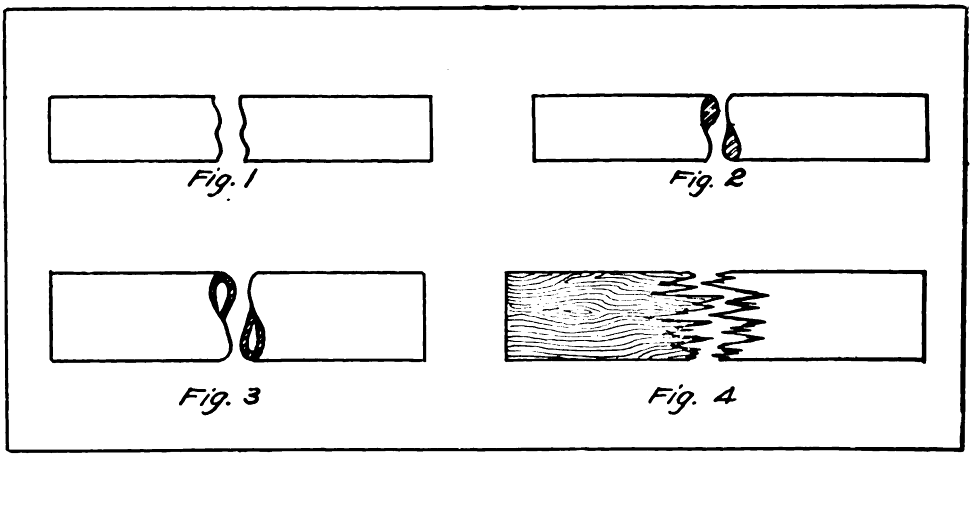
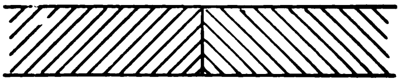


Fig. 1 Fig. 2

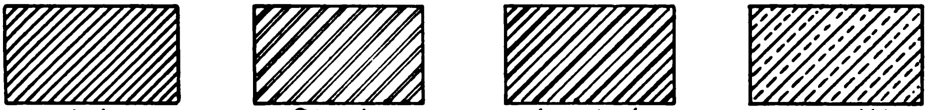
Fig. 3 Fig. 4

CONVENTIONS

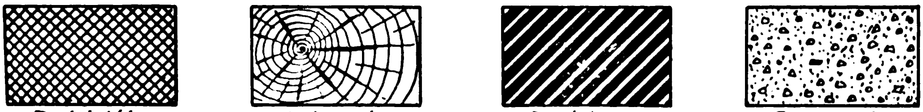
Hatching — In making a drawing of a section the portion where the plane passes through solid substances are "hatched" This consists in covering these portions of the surface with lines of various kinds, to represent the fact that solid substances is cut; and also to represent according to accepted methods, the kind of substance that is cut by the plane. For small surfaces the lines are quite close together. The lines for hatching are drawn with the 45° triangle When two surfaces cut by the plane of section join along a line, one of the sets of lines for hatching must be inclined one way 45° and the other one the other way 45°, so as to distinguish the separate pieces readily.



Material Conventions



Cast Iron | Steel | Wrought Iron | Composition



Babbitt | Wood | Rubber | Concrete

Line Conventions commonly used in Mechanical Drawing

Visible Line ————————

Shade Line ————————

Invisible Line - - - - - - - - - - - -

Center Line —— - —— - ——

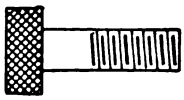
Extension Line — — — — — — —

Dimension Line ———— ————

Machine Conventions

Screw Thread

Pipe Thread



Knurled Surface

Shaft Bearings

Open Spring

Closed Spring

Some Notes on Induction Motor Connectoins

E. AUSTIN

While induction motor connections are often looked upon as being complicated and difficult to follow, in point of fact, if anything, they are simpler than those of other motors. In this article it is intended to deal primarily with the various methods of connecting an induction motor up to the supply mains; but in order that the reader may gain a firm grasp of the subject, it is well that he should know something of the connections inside the motor also.

We shall consider two- and three-phase induction motors only, since these are the types principally used in industrial service. These, of course, are of two kinds, viz., squirrel-cage and slip-ring motors; but it may be mentioned at the outset that the difference in these two

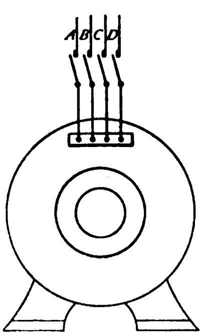


Fig. 1.

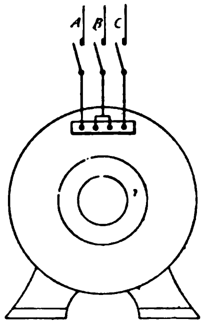


Fig. 2.

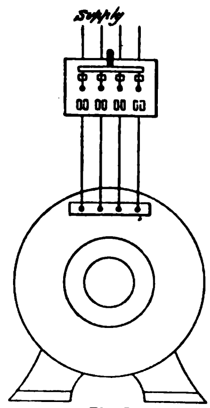


Fig. 3.

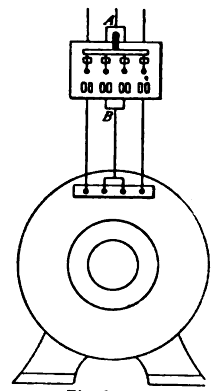


Fig. 4.

types exists entirely in the rotor, the stator being of the same construction in each case. In considering the stator connections, therefore — internal or external — any arrangement is applicable to either types. For reasons which will be duly given, however, the same starting arrangements in the stator circuit are not employed for both types.

The stator of a two-phase induction motor is wound in two separate circuits, one for each phase; each circuit or winding naturally has two ends — a starting and finishing end: consequently, in the case of a two-phase motor there are four stator terminals to which the four supply mains are connected.

Fig. 1 shows a two-phase squirrel-cage motor connected to the supply. It will be noticed that the four stator terminals are simply connected to the line wires, a four-pole switch being interposed in the circuit. The two terminals belonging to one phase of the motor are generally marked with the letter A, whilst the other two terminals belonging to the other phase are marked with the letter B. As a rule, supply companies also mark their cables in a similar manner, in order that persons may know the wires belonging to each phase. Failing this, however, the two wires belonging to one phase can readily be found by means of a voltmeter or lamp. Any two wires found to have voltage between them belong to one phase. In Fig. 1 the line wires are marked A, B, C, D. The wires A and B belong to one phase, and C and D to the other.

In the event of the motor revolving in the reverse direction to that desired, interchange any two wires of one phase, viz, A and B, or C and D. This applies to any four-wire two-phase system.

There are one or two supply companies who distribute two-phase currents by means of a three-wire system, when three wires are brought into the premises instead of four. The problem of how to connect a two-phase motor with four terminals has proved a puzzle to many. The connections are shown in Fig. 2. It will be noticed that two of the terminals on the motor are joined together by means of a piece of wire, and the line wire B feeds both terminals. The other two line wires A and C are connected to the two remaining terminals. There are, however, two important things to be settled before connecting, as shown in Fig. 2. One is to decide which two terminals on the motor should be joined together, and the other is — which of the three line wires should be connected to the junction; in other words — which is the wire B in Fig. 2? If the makers of the motor are advised of the fact that the machine is to run on a two-phase three-wire system before despatch, they will make all necessary connections on the motor, and the two difficulties in connecting up are reduced to one. The wire B, or common return, should readily be located; for, since it has to carry more current than the other two wires, it should be larger in section. If, however, this is not the case, procure a voltmeter and test the voltage, when it will easily be discovered, for the voltage between either of the "outers" A C (Fig. 2) and the common return B is only .7 of that between the "outers" A and C.

The two terminals on the motor to be joined together should be the beginnings of the two windings. It is, of course, possible to find the ends of each winding by means of a battery and galvanometer, or lamp; but to distinguish the beginnings from the finishing is a matter of inspection, which means removing the end covers. Having located these ends and joined them together, connect, as shown in Fig. 2. Should the motor revolve in the reverse direction to that desired, interchange the two "outers" A and C.

The great objection to starting a squirrel-cage motor with a simple switch — as shown in Figs. 1 and 2 — is that the motor takes a very heavy starting current; in fact, three or four times the full-load current. The result is that central station engineers will not allow large squirrel-cage motors to be started with a simple switch, as shown in Figs. 1 and 2.

It may here be remarked that although a squirrel-cage motor takes such a heavy starting current, the starting torque is by no means proportional to the current. The starting torque of a squirrel-cage motor is exceedingly small, and they are quite unsuitable for starting on heavy loads. When starting a squirrel-cage motor, always see that it is unloaded.

In order to reduce the starting current of a squirrel-cage motor an arrangement known as an auto-transformer is frequently employed for starting motors above 5 h.p. This device reduces the pressure at the motor terminals at starting, and consequently reduces the current also.

Fig. 3 shows a two-phase motor connected up to an auto-transformer. The type of auto-transformer here shown is as manufactured by the British Westinghouse Company, and is undoubtedly one of the best types on the market. The transformer itself is enclosed in a case, on the top of which is a throw-over switch having two sets of contacts; when the switch is thrown on to the contacts marked "starting," the pressure applied to the motor terminals is considerably below that of the line. When the motor has gained speed, the throw-over switch is then transferred to the contacts marked "running." The full line pressure is then applied to the motor terminals, and the machine is ready for taking its load.

The auto-transformers, as manufactured by the British Westinghouse Company, are provided with eight terminals — four line terminals, and four motor terminals. These are marked "line" and "motor" respectively, and in the case of a two-phase motor it simply remains to connect up, as shown in Fig. 3. To reverse the direction of rotation, interchange any two line wires of one phase.

When two-phase current is supplied by means of three wires, as in Fig. 2, the same auto-transformer can be employed by joining two of the line and two of the motor terminals, as shown at A and B (Fig 4). The terminals to be joined are the middle ones, as shown in the sketch. They are generally marked A2, B1.

Fig. 5 shows the internal connections for a Westinghouse auto-transformer. The black dots correspond to the switch contacts on the front of the case, and the wires L_1, L_2, L_3, L_4 and A_1, A_2, B_1, B_2 the line and motor wires respectively. The transformer windings are represented by the zig-zag lines marked "the auto-transformer", the wires C and C_1 are connected to tappings on the transformer. These wires are connected before despatch, and it may not be necessary to interfere with them. Should the motor, however, exert insufficient torque at starting, the torque may be increased by connecting the wires C and C_1 to tappings, giving a higher voltage. On the other hand, should the torque be ample and the starting current too heavy, the wires C and C_1 should be connected to tappings giving a lower voltage. It will be seen by reference to Fig. 5 that in order to increase the voltage at starting the wires C and C_1 must be connected to tappings marked with numbers higher than those to which the numbers C_1 and C were originally connected to.

It should be understood that the instructions given above for connecting auto-transformers apply to auto-transformers of the Westinghouse Company's manufacture. This type has been chosen because they are largely used in all parts.

Fig. 6 shows the connection for a two-phase slip-ring induction motor. It will be seen that the four stator terminals are connected to a four-pole simple switch, while the three brushes which rub on the slip-rings are connected to a starting resistance when the connections are complete. It may be mentioned that the advantages which the slip-ring induction motor possesses over the squirrel-cage motor are three-fold. First, by inserting resistance in the rotor circuit at starting, the starting current can be reduced to a low value; secondly, the resistance in the rotor circuit enables the motor to start against very heavy loads; and, thirdly, with a suitably designed resistance the speed can be varied over a very wide range while the motor is working. When the starting resistance is used for the latter purpose the resistance employed is frequently of the liquid type, owing to the large amount of heat to be dissipated. In any case it must have three terminals, and is connected as shown in Fig. 6. To start a slip-ring motor all the resistance is first inserted in the rotor circuit; the main switch is then closed and the rotor resistance gradually cut out of circuit.

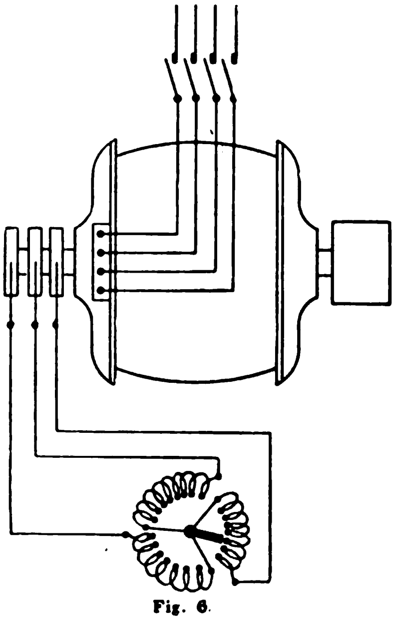


Fig. 6.

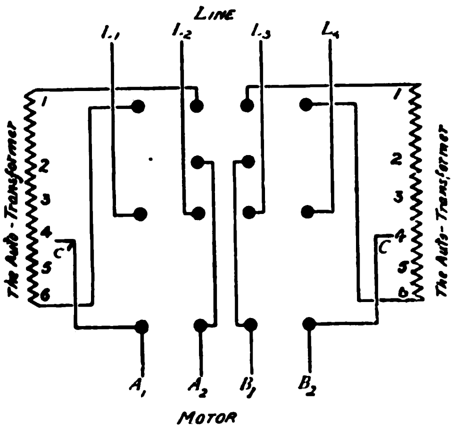


Fig. 5

Having considered the various methods of connecting up two-phase motors, we will now turn our attention to the type more generally employed, viz., those supplied with three currents differing in phase by 120 degs. known as three-phase motors.

Motors of this type, as might be supposed, are provided with three separate stator windings — one for each phase. Unlike the two-phase motor, however, the six ends of the windings do not, as a rule, form the machine terminals, but the coils are so grouped as to reduce the number of terminals to three. In some cases the three starting ends of the coils are joined to a common point, and the three remaining ends become the machine terminals. This is known as the "Star" method of grouping, and is shown diagrammatically in Fig. 7. When the coils are so grouped the voltage at the terminals is 1.73 times greater than that between the ends of any one phase winding. Another method of grouping the coils is known as the "Mesh" grouping, and is shown diagrammatically in Fig. 8. In this case the starting end of one phase is connected to the finishing end of the next, and this is done with all three phases, so that a completely closed circuit is formed. At each point where the coils are joined (A B C, Fig. 8) a tapping is taken off, which gives the three terminals of the machine. It is obvious in this case that the voltage between any two line wires is the same as that between the ends of the coils, but the current in the coils is 1.73 times greater than that in the line wires.

In the majority of cases it is quite unnecessary to know anything about the method of grouping the stator coils, since these connections are made at the manufacturer's works, and consequently the man who connects up the motor to the supply simply has to deal with the three leads protruding through the motor case. In one instance, however, which we shall presently come to, a knowledge of the "star" and "mesh" grouping is very desirable.

For the present we shall confine our attention to ordinary cases most generally met with in practice. To connect a three-phase squirrel-cage motor up to the supply, simply connect the three stator terminals to a three-pole switch in a similar manner to Fig. 2, except, of course, that the middle switch blade is connected direct to the middle terminal on the motor instead of two terminals, as in Fig. 2. To reverse the direction of rotation, interchange any two line wires. When an auto-transformer is employed the instructions given for a two-phase motor on a three-wire system may be worked to, except, of course, joining two terminals on the motor (see Fig. 9). The direction of rotation may be reversed by interchanging any two line wires, as in the case when a simple starting switch is employed.

A three-phase slip-ring motor would be connected up as shown in Fig. 6, the only obvious difference being that there are three stator terminals and consequently a three-pole switch would be employed instead of a four-pole; the starting resistance connections are identical. Here, again, the direction of rotation may be reversed by interchanging any two line wires.

It has been explained that when the coils of a three-phase induction motor are connected in "star" the voltage at the terminals, or back E.M.F. of the motor, is 1.73 times greater than when the coils are in "mesh"; consequently, if we join the coils in "star," the motor will take less current when connected to the supply than the same motor would take were the coils in "mesh." This gives an excellent method of starting a squirrel-cage motor, for, with the aid of a throw-over switch, the coils may first be connected in "star," and—after speed is obtained—in "mesh." Thus the throw-over switch takes the place of the auto-transformer — a less expensive piece of mechanism.

In order to change the grouping of the coils from "star" to "mesh," it is obvious that the motor must have six terminals—that is to say, the six ends of the coils must be brought outside of the motor case. Moreover, it is necessary to know the starting and finishing end of each phase. These can be found by testing with a galvanometer and by inspection of the coils. If the ends of the coils are not marked by the makers, it will be found convenient to mark them, as shown in Fig. 10, S_1, S_2, and S_3 being the starting ends of the first, second, and third phase respectively, and F_1, F_2, and F_3 the finishing ends of the first, second, and third phase respectively. Two switches are required — one an ordinary three-pole switch, and the other a three-pole throw-over switch.

Referring to Fig. 10, it will be seen that the three starting ends of the motor windings S_1, S_2, and S_3 are connected to the blades of the throw-over switch, and that on the top set of contacts of the throw-over switch are joined together, so that when the switch is thrown on to these contacts the three starting ends will be joined. This corresponds to the middle point of Fig. 7. The remaining three motor terminals F_1, F_2, and F_3 are connected to the main switch and to the other three contacts of the throw-over switch, as shown. These three terminals must be so connected that when the throw-over switch is on the bottom contacts, S_1 connects with F_2, S_2 with F_3, and S_3 with F_1. By tracing the connections in Fig. 10, this will be found to be the case. With the throw-over switch on the bottom contacts, the coils are clearly in "mesh," for the beginning of one phase is connected to the end of the next, and when the main switch is closed the current feeds at the junctions.

To start, the throw-over switch is first thrown on to the top contacts and the main switch is then closed; the current then feeds in at the points A, B, C (Fig. 7). As soon as the motor attains speed the throw-over switch is transferred to the bottom contacts; the current then feeds alternately at the junctions A, B, C (Fig. 8), when the motor is ready for taking up load. The direction of rotation may be reversed by interchanging any two line wires, in the same manner as when an auto-transformer or simple starting switch is employed.

The instructions given in this article will be found to clear most difficulties which arise when connecting induction motors to the supply mains; and it is hoped that this information may prove useful to mechanical engineers and to others whose experience has not brought them into contact with motors of this type.

Fuses have not been shown in the sketches for the sake of simplicity and economy of space. Further, in the case of squirrel-cage motors it is now becoming common practice to work without them, because the starting current is so much above the working current, and if the fuses are to stand at starting, they must be far too heavy to protect the motor from over-load whilst at work, hence the reason for this practice. It is far better, however, to fuse a squirrel-cage motor for its specified over-load, and to short-circuit the fuses whilst starting, than to adopt the practice of dispensing with fuses altogether. Slip-ring motors may be fused in the usual manner, because the starting current is not necessarily heavy.

—*The Engineer in Charge.*

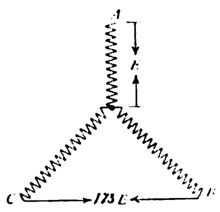


Fig. 7

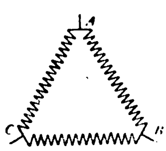


Fig. 8

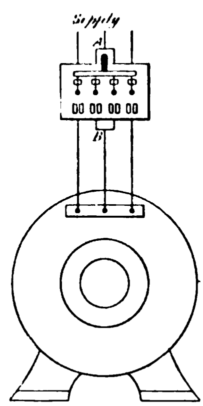


Fig. 9

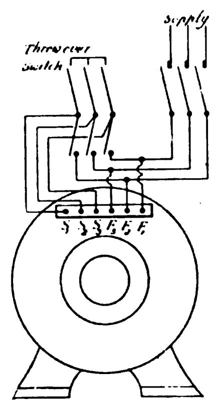


Fig. 10

Don't get the erroneous idea that an electric fan is only useful in hot weather, then must be put away to rust and decay. A good electric fan will last for years, and the more it is used the better.

Many times, both winter and summer, the sun refuses to shine, the weather is otherwise disagreeable and milady is in a quandary as to how she can quickly dry her hair after the shampoo. Nothing, not even "Old Sol" himself, accomplishes this so well as a gentle, steady breeze from the electric fan.

The price of platinum is decreasing, being about **$32** per ounce at present.

Notes on a 1 h.p. Oil-Driven Electric Light Plant

BY A. O. GRIFFITHS

A few notes on experiences in running an electric light set, consisting of oil engine and belt-driven dynamo, might be of some interest to those who may think of installing this form of current generation. The set referred to consists of a petroleum engine 3½″ bore, 5¾″ stroke, driving by a 2½″ belt an overtype drum dynamo with a capacity of 15 amps. at 50 volts.

The above, both of home manufacture, were to be tried as a mode of lighting a small cycle shop, with grocer's shop adjoining, in the country, where there is no gas, something a little better than oil lamps being desired. The main anxiety, as will readily be understood, was whether it would be perfectly reliable, and some little hitches, and the way they were overcome, is what I think may be of a little interest; the thing was all right in theory, but what about practice? The set has now been running fifteen months, pretty nearly every night. It is one thing to run a set say in one's own workshop, where, if there is a slight hitch, it is nothing to stop for five minutes, set it right, and then be off again. It is a different thing to light a shop in a public street, where every flicker is remarked on, and a total stoppage for even a minute makes one wish one had never been born. But oh! the compensations when one can smile a superior smile on the wretched oil lamps across the street, and survey their cool, clean, brilliant rival in one's own window, feeling as reliant as on the great central station in the city.

The dynamo can be dismissed in few words; it has caused absolutely no stop. The only trouble connected with it was, that the bearing next to pulley used to get terribly hot and required standing over with an oil can in hand for 10 minutes together at times; it would drag the voltage down from 50 to 40, or less, if not watched. The belt was crossed, and engine set to run overhand, *i.e*,, the explosion took place on bottom half of revolution. This did little good. An absolute cure was effected by cutting out an oil-well in the body of the bearing, and converting it into ring-oiling, using a thin ring from an old free wheel for ring, and cutting a slot with a hack-saw in the bush, which is of Babbitt metal. Instead of requiring to be dosed every night, once in three weeks is quite often enough to look at it. I should just like to state here that I do not see why a 2½″ belt should have to be so tight for the power it transmits, for it requires to be kept fairly tight. The average load does not exceed 130 c.p. or so, say 1 h.p. The belt travels about 1,900 feet per minute. Pulleys are 18″ and 3⅝″ diameter, centres about 5 ft. apart. By the tables it should easily do three or four times this.

As to the engine. This is the uncertain factor in the reliability of the set. The first trouble to be tackled was, that although everything might work perfectly on commencing the night's run, in a short time the engine would be racing furiously, and the voltage steadily dropping. It was some time before it was discovered that the top of the small reservoir supplying the oil to vaporiser being left open, the vibration of the engine caused some kerosene to spout out of it in fine spray on to the belt; hence the slipping. Once found, soon remedied by fitting a good lid.

Trouble No. 2.—Exhaust valve casting getting a blood-red heat when running at full power, spoiling the valve and asbestos joint and causing the latter to blow out every few nights. This baffled me for two or three weeks. I finally found that in my anxiety to ensure a free exhaust, I set valve to open too early in the stroke. An alteration in the timing effected a perfect cure.

Trouble No. 3 — Noise.— When it is mentioned that the room in which the set is situated is only about 10 ft. by 6 ft. or so, and that it is adjoined on two sides by houses, and on another by a road, it will be seen that this is an important point. Even a 1 h.p. oil engine can make a rare clatter if not looked after. Remedy: A pit, 2 ft. cube, was dug in the floor of room, the exhaust led into one bottom corner, the hole filled with moderate sized stones, and tiles put down again, all crevices being plastered up, except where the exhaust exit pipe leaves, at opposite top corner going to chimney. It is now absolutely silent, and it takes no room, as that part of floor is used just the same as the rest. Of course, all brasses are carefully looked after, and never allowed to slack, also the air inlet is furnished with a good size pipe. Result: Satisfaction to self and neighbors. This point does not affect the reliability, but it is important nevertheless.

Trouble No. 4.— Irregular speed. —By this I do not mean the inherent cyclic variations of the explosive engine; the one in question has two flywheels of 18″ diameter, and runs at 380 revolutions per minute. It does not cut out explosions at all, and while an experienced eye might detect the "trade mark" of the oil engine in the lamps, no ordinary spectator would probably see any flicker. The irregularity referred to was very annoying, as at times the speed would vary between half and full for hours together. After careful watching it was found that the cause was invariably an infinitesimal speck of dirt from the oil on the face of the 3/8″ brass wheel valve which "dripped" the oil into the vaporiser. I suppose that, the valve being so large, the amount of lift from the seat was so small that the slightest suspicion of dirt would cause trouble. The oil had always been poured in reservoir through a petrol strainer, but this was not nearly fine enough; two layers of muslin were tried, with better results, but finally it had to be strained through four, with satisfactory results.

Trouble No. 5.— Blast lamp for heating tube going out. This did not exist for long; it was simply a matter of thoroughly cleaning lamp and nipple. One thing might be mentioned in this connection At one time, even if the lamp went out, the engine would run on for five minutes or so before slowing to any extent, giving one a chance to discover the fact, and light up, avoiding a stoppage. Later on, a heavy pressure was found necessary to keep the tube hot enough, also if the lamp went out, the engine stopped dead in about twenty seconds. This was cured accidentally by overhauling engine and improving the compression, after which the lamp used *less than half* the oil, and, indeed, was found almost unnecessary.

The above points may seem to some hardly worth while writing about, but the fact is that attention to them made all the difference between the installation being an intolerable nuisance and being a pleasure to run. That is why they are chronicled here.

A word about expense of running. A gallon of kerosene, costing 15 cents, runs the installation, giving 128 c.p. for 6 hours. It figures out at a shade over 4 cents per unit. Some favor gasoline electric sets, but give me, for stationary work, a substantial oil engine running at a comparatively slow speed. I sum up the respective advantages thus: — gasoline — compactness, direct coupling, instant starting; oil — slower speed of moving parts, greater safety, and, greatest of all, economy. I make it less than half the cost of gasoline.

I may add that, a storage battery for 50 volts being far too expensive to think of, a set of plates, cells, and separators was bought of a firm advertising in this journal. These were made up into a 6-volt battery of three positives and four negatives in each cell, which was charged through a 32 c.p. lamp continuously while running. From the battery, wires run to three 6-volt 4 c.p. Osmi lamps in the shop window and over the counter, controlled by one electric bell switch. This is found extremely handy if the "engineer-in-charge" is detained a few minutes from starting the main supply at lighting up time, or when a light is wanted for a short time.

— *Model Engineer.*

White mica, or muscovite, which is a relatively rare material, in leaves of great dimensions, is much in demand as a high-voltage insulator for electric currents, says *La Nature*. Large sheets of mica may come as high as $2,000 to $12,000 a ton. An average price is $400 a ton for Canadian micas, which have a sort of monopoly of this industry. The deposits in this country occur in connection with the pegmatites (coarsely crystallized granites). They have the fault of being very irregular; but there are often found, as accessory deposits, rare earths, whose normal occurrence is in the same rocks.

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EDITORIALS

On another page will be found a definite announcement that we are to raise the price of this magazine to $1.00 a year, 10 cents a copy, beginning with the October number. The number of pages will be materially increased so that a much larger magazine will be furnished to our readers.

We shall also furnish articles on a wider range of subjects than has been possible with our present number of pages. We shall continue our policy of giving our readers practical directions for building electrical apparatus, machinery of other descriptions and furniture.

We have in preparation numerous and important articles of this character including complete and specific directions for building wireless telegraph stations of any size and power which may be desired, the construction of dynamos of several patterns and capacity, the manufacture of a model steam engine and boiler, directions for wiring a house and numerous practical subjects.

We shall also include popular illustrated articles on noteworthy applications of electricity, interesting scientific discoveries and other topics of general interest.

You may thus be assured the magazine will not only keep up its present standard of interest, but will be greatly improved. As hundreds of our readers have told us it is now worth double the price, we are sure it will be after these improvements. Nevertheless we offer to our present readers the opportunity to obtain the enlarged magazine at the present price if you will *immediately* fill in the subscription blank to be found on another page.

We will allow you to extend your present subscription for a year beyond the time when it expires for 50 cents, the present price. If you will send $1.25 we will extend your subscription for 2 years; for $2.00 we will extend it for 3 years. If you are not a subscriber, but buy the magazine from a newsdealer, you may still take advantage of these offers.

Remember the offer holds good only until the September number appears. You must send your money this month because the price will be raised as soon as the September number is issued. Do not hesitate or delay. You will want the magazine and if you do not subscribe now you will later regret it.

Foreign subscribers, including those from Canada, must add postage which, for the enlarged magazine will be 25 cents additional a year for Canadian subscribers and 50 cents for those in other countries.

The new regulations for the manufacture of denatured alcohol which have just been announced by the commissioner of Internal Revenue will go into effect on Sept 1. These regulations carrying out the spirit of the new law passed at the last session of Congress are very much more liberal than those previously in force. It will be possible for any farmer to install a still on his farm and without excessive red tape, distill and denature alcohol from waste farm products. It is anticipated that a greatly increased production of alcohol will be the immediate result of this new law.

We again call our readers' attention

to the valuable book "Alcohol, its Manufacture and Denaturing" which gives full details of all the processes. We shall be glad to furnish it at the publishers' price, $1.00.

All previous premium offers are withdrawn under the special subscription offers which we are making in connection with the contemplated raised subscription price. No premiums or books will be given.

This number of ELECTRICIAN AND MECHANIC will probably be the first one received by several thousand persons who were formerly readers of AMATEUR WORK. We have made arrangements with the Draper Publishing Co. to combine this latter magazine with our own and to fill the unexpired subscriptions of AMATEUR WORK.

The April number of AMATEUR WORK is the last issue of that magazine which will be published. We are not able to furnish May or June copies of our magazine to fill out all the subscriptions, and have in most cases mailed the August number of our magazine as the first. Each subscriber will receive ELECTRICIAN AND MECHANIC for the number of issues due him from AMATEUR WORK. To those who may wish to get the July number of our magazine, which began a volume, we would say that as long as the supply lasts we will mail these copies on receipt of ten cents each. We have also a *very* few bound volumes for last year, the first volume of ELECTRICIAN AND MECHANIC, which we will be glad to furnish as long as they last at $2.00 each, bound in red buckram.

For the benefit of those who may think they will not get as expensive a magazine as the one to which they subscribed, we will reiterate what is elsewhere announced, that we propose to raise the subscription price of this magazine, beginning with the October number, to $1.00, and to materially increase the number of the pages. Our articles will cover practically the same field as that of AMATEUR WORK, and we hope that every reader will feel that the combined magazine is in all respects as satisfactory as that to which he subscribed.

We would welcome suggestions from our readers as to the kind of articles they would like to see in the magazine, and will do our best to publish such articles.

We have sent to every subscriber of AMATEUR WORK whose subscription is not completed with the mailing of this number, a reply postal card of a form prescribed by the Post Office Department. We beg that these be filled out promptly and returned to us, whereupon your subscription will be duly entered on our records.

We regret that we are unable to extend to readers of AMATEUR WORK the privilege of lengthening their subscription a year from the time of expiration at the present subscription rate of this magazine. This offer applies only to those who are at present subscribers to ELECTRICIAN AND MECHANIC and to new subscribers who begin with the current number.

Subscribers who are entered for both magazines will have their subscriptions extended without other notice than this.

We will inform our new readers who are interested in mechanical, electrical or technical books of any kind that our book department is prepared to fill orders for any book in print. We should be very glad to hear of your wants in this direction and to receive orders. In ordering books, whenever possible, specify the author and publisher, as it is often the case that several books on a subject have similar titles and cost different amounts.

If you are interested in animals, order one of our new twenty-five cent books. There are three of them, "Goats for Profit," "Utility Rabbits," and "Keeping a Dog."

Catalogues Received

From the Fort Wayne Electric Works, Fort Wayne, Ind. Bulletin No. 1094, Belted Direct-Current Generators, Type L.F. Bulletin No. 1095, Enclosed Alternating-Current Multiple Arc Lamps, 104-volt, Type ACM, Form C. Bulletin No. 1096, Type A Transformers. These three bulletins carefully explain the types and construction of the pieces of apparatus specified, with numerous explanatory illustrations.

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.]

Telephone Circuits

305. J. W. N., Boston, Mass., asks (1) What is the object of using "series" telephone lines? (2) What is the object of having one connection in common between primary and secondary winding of a telephone coil? (3) Why does a telephone talk "flat" when secondary terminals are reversed?

Ans. (1) This method allows economy of line wire, but its use is largely limited to rural circuits. Such lines suffer more inductance from neighboring wires than do the bridged or multiple sort. (2) This saves one connection at the hook switch. (3) In using a telephone a person is also talking to himself, for his own receiver is in series with the line, and a current flowing in the wrong direction in the receiver tends to neutralize instead of intensifying the action of the permanent magnet.

Dynamo Building

306. J. C. W., Vandalia, Mo., asks (1) What size of wire to use on a 75-watt dynamo to give 25 amperes and 3 volts? (2) Where can an 8″ screw cutting foot power lathe be obtained? (3) Will a diploma from a correspondence school be helpful in securing a good situation?

Ans. (1) No. 12 wire on armature, No. 15 on fields. It would be helpful for you to read the description of the winding for the "plater" in Watson's "How to Build a ¼ h.p. Dynamo." (2) From the Seneca Falls Mfg. Co., Seneca Falls, N.Y., or from Sears, Roebuck & Co., Chicago. Almost any large hardware store is agent for various makes of such machine tools. (3) Of course no alliance exists between these schools and the manufacturing concerns, but the demand for intelligent or skilled labor is so great, that the schools are regularly besought to recommend good men. You ought to get all the education possible.

Rheostat

307. R. H. C., Nashville, Tenn., asks (1) If No. 24 German silver wire will carry 6 amperes, what size should be used for 10 amperes? (2) What is the "3-wire" system of electric distribution? (3) How can a small "buzzer" be made?

Ans. (1) Except for use in motor starting rheostats, a case in which the current is passing for a moment only, we should regard No. 24 wire as altogether too small for 6 amperes. Constant potential arc lamps of the enclosed sort operate on about this strength of current, and commonly employ No. 16 or 18 wire. A 10-ampere arc lamp would have about No. 12 wire, but No. 14 might answer if the ventilation was good. (2) This was described in the May issue. (3) You can readily modify a cheap electric bell for the purpose, by weakening the spring, reducing the size of the hammer, and limiting the motion.

Gas Engines—Magnetos

308. R. H., Sheridan, Ind., asks (1) If there is any way to run a "Paradox" gas engine on natural gas? (2) Would the output of a telephone magneto generator be increased by putting on double sets of magnets, so that the armature was acted upon by a sort of "Manchester" type of field?

Ans. (1) In this part of the country we have no opportunity to use natural gas, and therefore are rather ignorant o its peculiarities. You might well address the makers of the engines. (2) Yes, each set of magnets could extend half way onto the cast iron pole pieces.

Engine

309. G. H. I., ——— asks (1) If the cylinder of a gasolene engine can be made of Babbitt metal? (2) Is a 3/32″ drill large enough to drill the ports of a 1½″ × 3″ steam engine? (3) What would be power of such an engine?

Ans. (1) No, the heat would melt it. (2) No, unless you intend to drill a lot of holes and chip out the metal between. The opening ought to be not less than ⅛″ × ¾″. (3) One-eighth of a horse power.

Gravity Battery

310. J. L. T., Annandale, Minn., has made a gravity cell that worked for several days, and then failed to give a current. What was the reason?

Ans. You failed to recognize the principle that it is the passing of the current that keeps the two solutions,—sulphate of zinc in top and sulphate of copper in bottom,—apart. If you leave the cell on a completely open circuit, the two solutions will inevitably mix. As soon as the copper reaches the zinc, local action sets in that almost entirely suppresses the main current. You will have to scrape the zinc clean, and be careful to leave the current flowing, say through a 20-ohm sounder, even though not wanted. True, a waste of zinc results, but not so much as by the unnecessary cleanings. Keep a generous supply of the "blue stone" in bottom of jar.

Telegraph Line

311. E. R., Ripley, O., asks (1) What is the resistance of one mile of No. 12 iron telegraph wire? (2) What would be the resistance of such a line using a ground return? (3) How many carbon-cylinder batteries would be needed to operate such a line having two 20-ohm sounders?

Ans. No. 12 B.B. galvanized iron wire has about 33 ohms per mile; X. B.B., 28 ohms. Such wires are estimated in the Birmingham rather than the Brown & Sharpe gauge. (2) The ground resistance varies greatly with the locality and season. Perhaps 50 ohms for the entire circuit would be a good guess. (3) About an eighth of an ampere would be desirable, and if you use the open circuit system, ten Leclanche cells at each end of line will be needed.

Wire Gauge

312. H. K., Austin, Minn., has an English wire gauge and asks if it is the same as a Brown & Sharpe, and if different, how much?

Ans. Iron wires and sheet metals are regularly measured with the English (Birmingham wire gauge, B.W.G.); copper wires with the American,—Brown & Sharpe. The numbers are quite different, but for a large part of the scale, the same wire would be called two numbers higher on the B. W. G. than on the B. & S. For instance, No. 12 wire on B. & S. guage is about .081″ dia.; the nearest to this on the B. W. G. is .083, and it is called No. 14. There is really the Old English or London gauge, the Stubs' or Birmingham, and the New British Standard, but we will not try to confuse the situation any further by exposing these intricacies.

Gutta Percha

313. C. F. W., Dayton, O., asks (1) What is gutta percha? (2) Where is the magnetic meridian? (3) What size of gears should be used to drive an emery wheel at normal speed?

Ans. (1) Gutta percha is the hardened juice of the *Isonandra Gutta*, a tree that grows in Borneo, Singapore, etc. (2) The magnetic meridian is the direction in which a compass points; this varies for different parts of the world, and indeed is constant in no one place. Extreme changes seem to be separated by about 250 years. In London, in 1900, the compass pointed 16° from the true geographical pole, but at that time a line through Lansing, Mich., Columbus, O., and Charleston, S.C., pointed exactly through the magnetic pole and coincided with the geographical meridian. (3) Gears are too noisy; you ought to use belts. Let the periphery of wheel travel at about 700 feet per minute.

Steam Engine

314. F. P. H., Baltimore, Md., has an upright steam engine, with 1⅝″ × 2″ cylinder; supply pipe is ⅜″ in dia. and flywheel 4¾″ in dia., with a round rim ⅜″ thick. He asks (1) What steam pressure would be needed to enable engine to generate ⅛ h.p. and run a dynamo for electric lighting? (2) Would a heavier flywheel be needed, say one to allow use of a 1″ belt? (2) What kind of a boiler would be suitable, yet easy to make?

Ans. (1) About 60 lbs. (2) Yes, one at least 6″ in dia. with 1″ rim would suffice; perhaps a flat face is about the easiest to provide; but a belt 1″ wide is unnecessarily large to transmit ⅛ h.p. A ¼″ dia. round belt running in V grooves would be quite suitable. (3) A mercury flask makes a very good boiler for such experimental use; such vessels are of wrought iron, about 5″ in dia. and 12″ long, with a screw plug at top. You could make a side bottom connection in addition, for feed water supply and for a second connection for the water column. Suspend the whole structure in a small laundry stove. The flasks can be obtained from wholesale druggists for 50 or 75c each.

2-Cycle vs. 4-Cycle Engines

315. C. K., Joplin, Mo., asks what are the respective qualifications of 2-cycle and 4-cycle gasoline engines?

Ans. Both forms have their good features, and some concerns build both. In general the two-cycle is cheaper to build, more noisy at the exhaust, and consumes more gasoline than the 4 cycle. The latter is usually more reliable in starting.

Small Dynamo

316. F. H., Fulton, Ill., asks (1) What is the proper winding for a 6-slot armature 3" in dia. and 4" long? Field is of the Manchester type wound with No. 17 bell wire. (2) What is the construction of the "tomato-can, iron chip, caustic potash, paraffin oil" battery? (3) Can a "Little-Hustler" motor be used as a generator?

Ans. (1) Six slots are too few for an armature of this size; 16-wound would be better. You did not state what voltage you desired, but we would think No. 16 wire suitable. Bell wire is not economical for either field or armature,—the insulation is so thick as to deprive you of getting on the maximum quantity of wire. (2) We do not think very highly of this battery. At best the can is short-lived, and the caustic solution is about the meanest stuff to get on the hands and clothes that you can find. (3) Probably not, unless you repeatedly magnetize the fields from a battery.

Magnetic Field (?)

317. D. A. M., Sligo, Pa., (1) Says he has attached an alarm bell to a magnetic field, but is unable to get any current. What is the reason? (2) An electro-plating dynamo has an armature 3" in dia., 1¾" long with a 6-segment commutator. What should be the sizes for rewinding to allow for operating incandescent lamps?

Ans. (1) We certainly do not understand your phraseology and are at a complete loss to grasp your idea. Please make a complete sketch of your apparatus, with explanation. The only way we know to make a magnetic field is by sending an electric current around a coil of wire; ordinarily there would be iron inside such a spool, as in case of the field magnet of a dynamo. (2) With only 6 segments, you cannot wind armature for more than 25 volts. Use No. 18 wire on armature, No. 21 on shunt fields.

Luminous Tube

318. F. B. F., Passaic, N.J., asks what is the sort of electric lighting that employs long tubes, extending, perhaps, all around a room, and emitting a pink light?

Ans. It is the J. McFarlane Moore system of vacuum tube lighting. Electric discharges from induction coils are sent through the rarified air. It gives a sort of dim, religious light.

Perpetual Motion

319. F. B. W., Hagerstown, Ind., asks if it is possible to set up a dynamo, storage battery and motor, so that the motor would run the generator, the generator charge the battery, and the battery run the motor, thus keeping up a perpetual motion and perhaps have some power left over to run other machinery?

Ans. No, this is impossible; the motor could not return much over half the power delivered to the generator. In your arrangement would not the battery be superfluous, except as a device for merely starting?

Wireless Telegraph Receiver

320. B. X., Cape Cottage, Me., has made a simple wireless telegraph receiver, consisting of needle resting on carbon knife-edges, and asks (1) If the crackling and snapping in the telephone can be suppressed? (2) Will copper wires larger than No. 14 be of advantage?

Ans. (1) From your experimental work we feel sure that you know more of the working of wireless telegraph apparatus than we do, and therefore feel rather undisposed to try to advise you. However, we should imagine the false noises in the telephone to be due entirely to unnecessary or unintentional movements of the needle. Vibrations due to air currents or jarring of the floor would readily keep the needle in a continual movement. The use of a permanent magnet,—which you have omitted,—below the needle was intended to prevent some of these varying contacts; the presence of the magnet would, however, reduce the sensitiveness of the instrument. (2) We do not know; the only sure way would be to try it.

Battery and Series Dynamo

321. J. C. P., Tampa, Fla., has a water wheel series dynamo for 50 volts and .8 ampere. Alone it will light 8 3½ c.p. lamps, but by connecting machine in series with an Ajax motor and 85 somewhat decrepit dry cells, 20 16 c.p. 101 volt lamps can be lighted. How can this increased output be explained?

Ans. You probably keep the current flowing but for a few moments at a time, for even in the first case you are working the dynamo at an output of about 2 amperes. In the second case more than half the energy probably comes from the batteries, but 20 such lamps consume nearly 10 amperes, and we do not think the wires on the dynamo could long stand that current; the dry cells, too, would be quickly run down. Just why you have the motor in circuit is not clear. Why not leave it out?

Telephone Generator

322. V. A., Beaver City, Neb., asks (1) What size of alternating current generator would be needed to supply about one and one-half times the current of a 5-bar machine, and allow for lighting an 18 or 20 c.p. lamp in addition? (2) What size of water wheel, connected with a 1"

pipe from a 5′ × 5′ flume with 4′ head would run the dynamo? (3) How should connections be made so as not to vary the light when ringing?

Ans. (1) We do not think you could well utilize a single machine for this double purpose; the ringing requires about 300 volts alternating, but the lamp could not well stand so high a voltage. We would suggest a separate machine wound for about 50 volts. (2) With such a low head, a 1″ pipe would be entirely inadequate; possibly a 3″ pipe might answer, especially if you are able to get something of a draft pipe for the outlet. Wheel should be of the turbine sort, about 5″ in dia. (3) Water wheel running, especially in such small sizes, is subject to wide fluctuations of speed, with change of load, and we do not think you had better try to eliminate the fluctuations. A storage battery equipment would accomplish the desired result, but be unduly expensive.

Wireless Telegraphy

323. J. A. M., Lowell, Mass., asks With the stations both on hills, with houses and trees between, using telephone receivers at receiving stations, and aerial wires forty feet high, what size spark would be needed to send a wireless message one and one-half miles?

Ans. This is a question frequently asked concerning wireless telegraph apparatus, and one of the most difficult to answer, definitely. The size of spark required would depend very largely upon the rest of the apparatus used. Under the conditions as stated you would need a coil designed to give a 6″ spark and operated by a storage battery. The spark gap should be adjusted to 2½″ or 3″ as this gives much better results than when set at their greatest distance. In commercial systems the rule is to cut down the spark gap 1/20 to 1/5 of its greatest distance. See A. T. Collins' "Manual of Wireless Telegraphy."

Specific Gravity

324. R. P. C., Tampa, Fla., asks (1) How to find the specific gravity of storage battery electrolyte with a hydrometer? (2) What is meant by Pb_3O_4 and PbO in regard to the part used in storage battery plates? (3) Which pole of a wire is it that gives off the bubbles when you put two wires in water?

Ans. (1) Directions for using various forms of hydrometers can be found in any standard text book on physics. The instrument may be graduated to read the specific gravity directly or on various arbitrary scales which are used for various purposes. (2) The symbols Pb_3O_4 and PbO are the chemical symbols of two oxides of lead, the change from one to the other furnishing the energy of the storage battery. (3) The positive pole gives off bubbles of hydrogen in a single cell.

Electric Stove

325. L. P., Ponce, P.R., asks (1) What length and size of iron wire to use for an electric stove to be operated on a 110-volt 5-amp. circuit? (2) How to make a rectifier that will change alternating into intermittent direct current? (3) Do trees, chimneys, flagpoles, telegraph or light wires have any effect on wireless telegraph transmissions?

Ans. (1) About 7 lbs. of No. 16, B. & S. gauge, will suffice; it will be advisable to have a sliding contact, so as to use more or less of the wire, and thereby having some control over the current. The choking effect with alternating current will allow less to flow than with direct. (2) With 60 cycles, an ordinary 4- or 6-pole motor will answer. Two collector rings must be added, and connected as a rotary converter. It must be started as any synchronous motor, and then within the limits of overload, alternating current may be led to the rings, and direct taken from the commutator. The current will be steady rather than pulsating. (3) Yes, hence messages are much more readily transmitted over water than over land.

Small Dynamo

326. G. M. DeRoss, Jennings, La., sends a sketch of a small dynamo in which it is proposed to use an armature 3″ in dia. end 3″ long, with 16 slots, each 5/16″ deep and wide. Field magnet is of Edison style, with the two cores 1″ x 1½″ section. He asks what winding will give the largest output and allow for charging storage batteries?

Ans. You do not state how many batteries you would like to charge at a time, nor do you specify the speed allowable. If you wish to charge 10 cells, a shunt winding for 25 volts will be appropriate. 2500 rev. per min. can be used. The armature is capable of acting under a much stronger field magnet than you propose, and with your weak field, there will be considerable sparking and poor regulation. With the existing field, you should use about 2½ lbs. per spool of No. 22 s. c. c. wire, and No. 18 d. c. c. on armature. With such a field as might be used, 4 lbs. of No. 20 on each spool, and No. 16 on armature would be possible; output of latter would be 10 to 12 amperes, as compared with 7 or 8 amperes with former. Watson's ¼ h.p. dynamo will give you good ideas of the relative size of parts.