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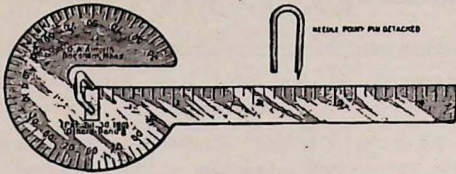
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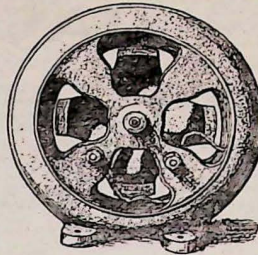
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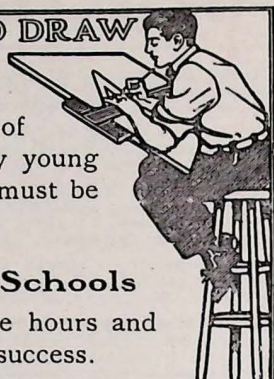
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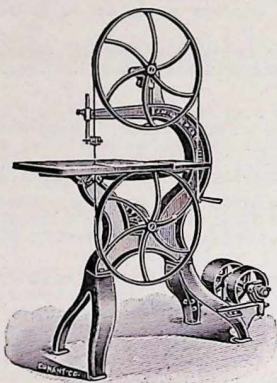
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A JOURNAL FOR AMATEUR WORKERS
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VOL. XVII

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NUMBER 10

ELECTRICAL ENGINEERING—Chapter X

Controlling Devices for Railroad Motors

A. E. WATSON

As explained in the preceding chapter, such motors ordinarily have series wound field magnets. Still, attempts are constantly being made to derive some benefit from the energy developed when cars are descending grades; but the regenerative principle that would allow return of the energy to the line can be accomplished with shunt wound motors only. Combinations of the two methods of exciting the fields might be used, resulting in a sort of a compound motor, whereby the desirable features of the series winding may be utilized for traction, and those of the shunt for permitting the generator action during the coasting. On level tracks not much economy is offered by this double use of the motors,—the only opportunity of returning energy to the system being during the stopping process. In hilly regions, however, the coasting may represent quite a proportion of the trip, and a saving of 30% in the total energy may be possible. Series wound motors are quite incapable of becoming generators under these conditions, for they cannot generate until the field magnet is excited, and as soon as the circuit is completed, current flows from the line

in the direction always to give the wrong polarity. Experiments are now being conducted with car equipments involving the regenerative principle, but have not yet demonstrated their worth or reliability. It is certain, however, that economy of operating expenses is the watchword of progressive power stations. This chapter will give a direct illustration of the abandonment of a good method of car control, for one that is still better, and the end is not yet. The explanation will be limited to past and present standard practice in American railways.

In starting a series motor, only enough electromotive force is needed to overcome the ohmic resistances, but as the speed increases, the pressure must be increased to overcome, in addition, the counter electromotive force generated in the motor. With a given load it has been found that the speed of a series motor varies directly with the voltage. For railway motors then, to have the qualification of variable speed, some means of procuring a variable pressure must be sought. An arc lighting dynamo is a machine for supplying a constant current and any number of volts, and

some original experiments with electric cars in Cleveland, Ohio, in 1886, were made using such dynamos for power. In order to allow the effective operation of the regulator on the machine, the different cars must be connected in series; though this can be done for reasonable limits of potential, and for a few cars on a short line, the system becomes impossible for a large number. The constant potential system of delivering the energy to the different cars is the only practicable one. Five hundred volts have been found to be a convenient pressure, and increased number of cars or increased loads merely mean more amperes. Of course large conductors are needed to transmit the thousands of amperes,—a fact readily seen from the size of the “feeders” alongside an electric railway. But each car is independent of the rest, the insulation of line and motors is not difficult, and the generators at the stations work under conditions of economy and convenience.

With this system decided upon, there is still the unavoidable necessity of a gradual acceleration of speed of the motors,—requiring first a small electromotive force, and increasing by steps, imperceptible to passengers, to the desired maximum. How can this variable number of volts be obtained from the approximately constant 500?

The most obvious and crudest solution is to put a rheostat in the circuit of each car and have this constantly under the control of the motorman. By Ohm's law the number of volts required to drive a current through a resistance is obtained by multiplying the number of amperes and ohms together. Obviously, by making the rheostat large enough, any desired current may be carried, and any number of ohms inserted in the circuit. Thereby, out of the delivered 500 volts the rheostat would waste any required number, and the motors would get the rest.

At start, all the resistance would be included; and the motors get the minimum voltage; at full speed all the resistance would be cut out, and the motors receive the full pressure. The energy thus wasted in the rheostat is degraded into mere heat, therefore fireproof constructions are to be sought, and those well exposed to radiation.

Sprague's installation in Richmond, Va., in 1887, may be said to be the first commercially successful electric road. In the motors for this and some subsequent lines, the builder sought to minimize the great loss in the controlling rheostats by letting the field magnet winding serve as the desired resistance. A number of separate sections were employed, some of them wound with German silver wire, and by a suitable “controller,” these coils were all connected in series at the start, and then after various combinations, to produce uniform gradations, were finally connected in parallel to give full speed. (Although thus involving the use of the words “series” and “parallel,” this controller does not represent the construction meant by the modern controller). Sprague's attempt at economy was rather an expensive one; at least his application of it to congested city traffic was unfortunate, for the slow movement of cars often required the resistance to be kept in circuit unduly long, and the result was a constant burning out of field coils.

The Thomson-Houston system was successful from the first, for in it, reliability rather than economy of control was regarded as of first consideration. A non-combustible rheostat, made of iron, slate and mica, quite apart from the motors, was used, and protected them from undue heat. Basic patents covering the use of the “magnetic” blow-out switch and the “under-running” trolley wheel were of course of immense value in giving this system the lead which it soon gained.

Most cars are equipped with two motors, many of them with four. Taking the case of the former, just how should one motor be connected with reference to the other? Economy dictated that at start the two should be in series, and for full speed, in parallel, but experimental work, though conducted with great zeal and considerable expense, revealed the difficulties of accomplishing, in a manner satisfactory to passengers and to motors, the transition from one condition to the other. Either a violent jerk was given to the car, or a dangerous flash was produced at the brushes of one of the motors or at the switches. Pending the more satisfactory solution of this problem, the simple expedient was adopted of permanently connecting the motors in parallel, with one rheostat to control the current for both.

Whatever the method of control of a railroad motor both directions of rotation are always to be provided, hence reversing switches are needed. Direction of rotation of an electric motor is not affected by exchanging the extreme terminals, as in exchanging trolley and ground connections; the current must be reversed in either the armature or the field, but not in both. A single reversing switch was originally used in the two motors, but with low resistance armature windings, a variation in brush contact readily causes an unequal current to flow in the two paths, with consequent overloading of one motor. By use of two reversing switches, the field resistance is added to that of the armature for each motor, and the combined amount of resistance causes a more equal division.

Fig. 37 shows a simple diagram of the entire connections. Current may be considered as coming from the trolley and passing to the pivot of the rheostat arm. As soon as contact is made with the resistance plates in the semi-circular trough, the path is on to the next but

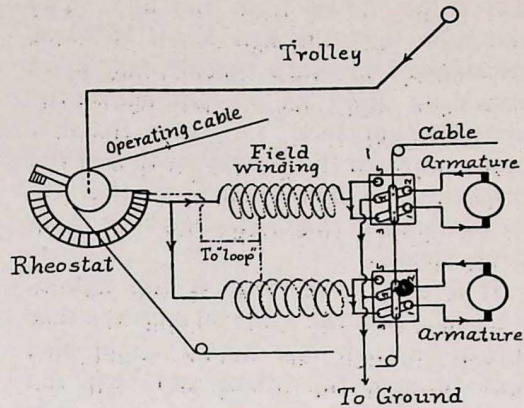


FIG. 37

Diagram of Car-Wiring, showing 2 Series Motors permanently connected in Parallel, and controlled by One Rheostat and Two Reversing Switches

last contact, where the current divides itself between the two motors. After flowing through the entire winding of the field spools, the currents pass to the reversing switches. These consist of insulated brass levers hinged at points 1 and 2, and arranged to be kept parallel with each other, and make contact with either 3 and 4, or 4 and 5. Wire from field connects to both 3 and 5, while point 4 is attached to "ground," *i.e.*, on frame of motor. Arrow heads show direction of current. The reader can imagine the switch to be moved to the other position, and he will then see that the arrows will be reversed in the armature circuits. About two and one-half turns of the rheostat handle moves the rheostat arm to its extreme position. When this position has been reached a new path has been provided, shown by dotted lines to "loops" left out in the field winding; by this path, about one-third of the winding is cut out, resulting in a weakened field and increased speed. The full field was available for starting, but a reduced strength for fast running.

To start the ordinary short cars equipped with two motors, 30 amperes per motor were often required, and therefore with the two in parallel, 60 amperes

had to be drawn from the line. The rheostats normally had about 20 ohms resistance, therefore considerably more than half might be cut out before the motors would start. Of course the first part comprised the greater portion of the resistance, so the movement of the arm to accomplish this reduction was relatively small.

It is easy to see that if the motors were in series, the same 30 amperes that flowed through one motor would also flow through the other, and that the start could then be effected with only one half the expenditure of energy required for the multiple or parallel arrangement. Also for slow speeds in city streets, the series connection would be more economical than the other, for with the former, only 250 volts would be impressed upon each motor, resulting in half speed, while with the latter the same could be accomplished only by wasting 250 volts in the rheostat and letting the motors receive the other 250. The economy of operation at full speed would not depend on the particular means of reaching it, but electric power was first applied to traffic in the most congested parts of the cities, and the need of reasonable economy in frequent starts and slow speeds made the demand for a "series-parallel" controller one that engineers at length were able to fulfill. The urgency of the case was greater in consequence of the overloaded condition of the power houses. Means of making large generators had not been found, the small existing ones were quite inadequate to meet the demands for heating as well as running the cars, and the reliable device that promised economy of the current met with quick reception.

The difficulties that previous experimenters had encountered in making the proper change from series to parallel arrangement of motors were overcome in a surprisingly simple and effective man-

ner by Mr. W. B. Potter, about 1891; he was then an assistant in the railway engineering department of the Thomson-Houston Electric Co., at Lynn, but is now the head of the department for that work with the General Electric Co., at Schenectady. In substance, his method was momentarily to short circuit one of the motors, thereby transferring the entire load to the other, then to disconnect the former and reconnect it to the circuit, but now in parallel rather than in series with the latter. In order to reduce the shock to car and active motor, and to provide a more uniform gradation of speeds, a resistance that had been in circuit at the start was reinserted just before this critical transition was made. Even with the two motors in series, their resistance was still too small to admit starting without the addition of some external resistance, but experiment showed that this need not be more than 6 or $6\frac{1}{2}$ ohms, instead of the 20 ohms formerly used.

To fit the great variety of railway traffic, a surprisingly large assortment of motors have been made with still greater diversity in the particular apportionment of the different combinations that may be found in the "controllers." A typical one may, however, be illustrated, the one mostly used for ordinary street cars. Diagrammatic illustrations of the successive circuits, as afforded by a progressive movement of the handle, are given in Fig. 38. In it a commutator is represented by a circle, with two radial brushes in contact, and a field winding by the coiled lines. Reversing switches are omitted. Twelve steps may be traced as follows:

1. Motors in series, with all the resistance.
2. " " " " two-thirds of "
3. " " " " one-third " "
4. " " " " no " "
5. " " " " shunted field winding.
6. A return to Combination No. 2.
7. One motor short-circuited.

8. One end of this motor open-circuited.
9. This end brought into *parallel* connection with other motor,—two-thirds of the resistance still included.
10. Motors in parallel with one-third of resistance.
11. Motors in parallel with no resistance.
12. Motors in parallel with shunted field winding.

It will be seen that in positions 1, 2, and 3 of the series connection, and 9 and 10 of the parallel, the resistance is included in the circuit, and these are denoted as starting points. Positions 7, 8, and 9 are the transitional ones, readily detected on the top of a controller by their absence—a considerable blank space suggesting the location; as here one motor only is doing all the work, the contact cylinder must not be allowed to stop on any of these points. 4 and 5, 11 and 12 are the economical running positions, the former corresponding to about one-half the speeds of the latter. In cities abounding in hills or grades, positions 5 and 12 are often omitted. Motormen are found prone to try to climb hills with the weakened field magnets, thereby demanding abnormal and ruinous currents in the armatures, when in reality these positions are intended for light loads, level tracks and infrequent stops.

Failure attended the first attempts to use these controllers from four causes. First, a single controller for a car was deemed sufficient, and as it was located beneath the floor, like the original rheostats, accessibility to examine or repair the numerous contacts was not given. Second, no indication was given to the operator as to the exact position of the contacts, resulting in disastrous arcs and melting of metal. Third, no means of suppressing the ordinary and inevitable arcs was provided. Fourth, no inter-locking devices were applied to prevent damage due to ignorance or carelessness. These were successfully avoided, respectively, by using two iden-

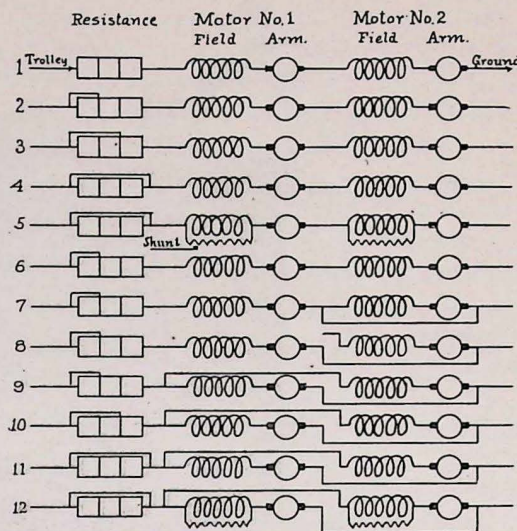


FIG. 38

Combinations in an Ordinary Street-Car Motor
"Series Parallel" Speed Controller

tical controllers, one on each platform; by using a notched wheel and roller that would allow definite positions only; by equipping the entire row of contacts with a magnetic "blow-out"; by locking the reversing switch, so it could not be turned while the current was on, and by providing additional switches for cutting one motor entirely out of circuit in case of accident to it, and preventing the controller handle from then being turned further than corresponded to the series position.

A view of the inside of such a series-parallel controller is given in Fig. 39. The movable contacts are mounted on a vertical cylinder, occupying the central position, and touch, successively the stationary "fingers" in a vertical row at the left. In the upper right hand corner are seen the reversing switches,—for convenience also mounted on a cylinder. Just below is the coil of copper ribbon that is in series with the main line, and used to energize the "blow-out" magnet. The entire back of the case forms one pole, while the other is a slab

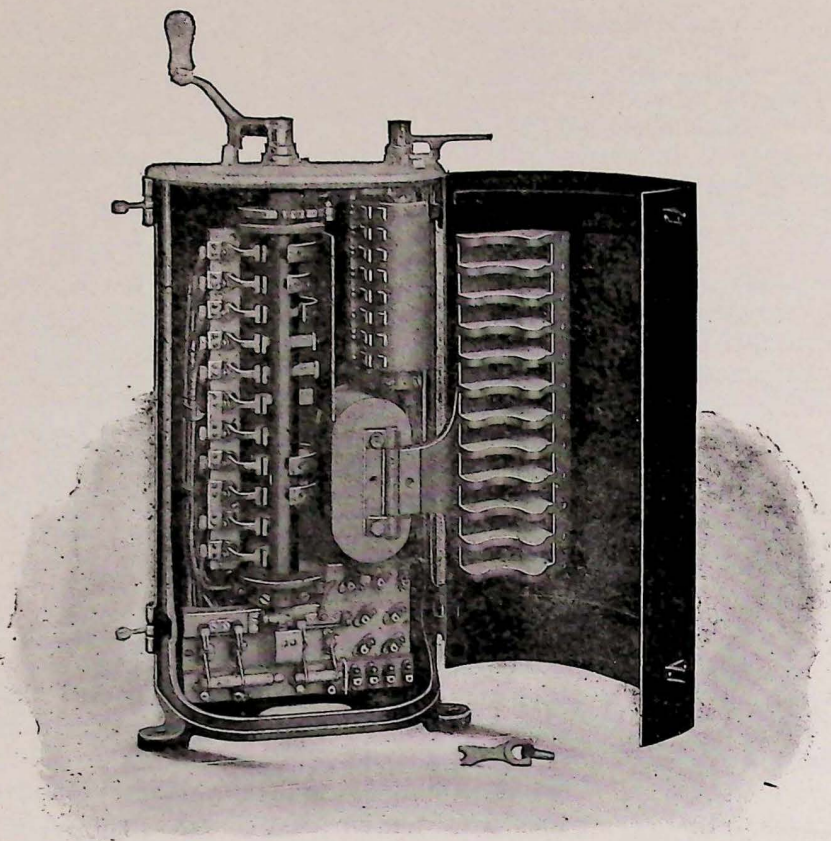


FIG 39
K-10 Series Parallel Controller

of cast iron long enough to reach the entire length of the main cylinder; in the cut it is shown hinged back to allow access to the contacts; on its inner face are mounted insulating partitions resembling shelves; these shut in between the contacts and so lengthen the path from one to the next as to diminish the likelihood of the formation of destructive arcs. At the bottom are the two cut-out switches, one for each motor. The oblong hole in base is for entrance of the flexible cables that make connection with the motors.

With light cars equipped with single motors, it may be possible still to find some of the old simple rheostats, but more than ten years' experience has demonstrated the highly satisfactory performance of the "controllers." Even in

cases where single motors are now installed, the controller is still provided, for though in such cases additional resistances must be inserted, and no economy of operation over the ordinary rheostat is offered, provision is, however, made, by a few simple changes, for the addition of the second motor with the full series-parallel advantages.

Occasionally, the insulation on the blow-out magnet breaks down, and the coil becomes short-circuited, then arcs, resembling those seen when a trolley wheel jumps the wire, come from inside the controller case, and cries of "fire" and wild panic result. All that needs be done in such an event is for some cool-headed person to pull down the trolley pole.

An interesting extension of the principle of controlling railroad motors, is given in the handling of entire trains. In order to maintain schedule time and preserve definite headway, uniform acceleration and braking must be provided, independent of the number of cars constituting one train. This condition can be met by the sole means of having every car equipped with motors, yet controlled from any one car by a single operator. The solution was first made by that eminent engineer, Lieut. Sprague, and adopted on the Boston Elevated road. In essence, the system consists in providing every car with the equipment necessary to allow it to be operated singly, then to couple any number in a train. The series-parallel controller on each car is not operated directly, but through the medium of a "master" controller. Electric couplings containing the requisite number of wires, make identical connections between all the cars, and when the master-controller is turned, the series-parallel controller on that car is at once operated, and also, in exact synchronism, the controllers on all the other cars turn on the current for their motors. The motorman does not even determine the rate of acceleration of the motors. He turns the handle at once to the full speed position, but the operating cylinder of the master-controller responds only as fast as air can escape from a checking cylinder, and the valve for the egress of the air is in turn controlled by a relay magnet in the main line; only when the current is below a certain minimum can the further rotation of the master cylinder take place. Removal of the hand from the knob at the top of the handle at once and automatically shuts off the power from the whole train. Ordinary automatic air brakes, such as are found on steam trains, are used for stopping.

Severe and crucial tests have been made on the effectiveness of this "multi-

ple-unit" method of control, as it is called. Trains have been made up, but without the use of the mechanical couplings. All gradations of speed, with such trying conditions as grades, curves and sudden stops were tried, yet no bumping or separation of cars ordinarily resulted. Indeed, in the ordinary operation of the trains around some of the sharp curves in the Subway, the mechanical couplings sometimes unhitch, but the motorman may be ignorant of the accident,—to him the train is still a unit.

The case of electric locomotives has brought out its own difficulties. If still operating at about 500 volts, the current required is very large,—perhaps 2,000 to 3,000 amperes. How best to get the current to the locomotive is a matter not yet satisfactorily settled, but with that provisionally cared for, the construction of the controllers has received special attention. The large contacts and considerable pressure needed to make good electrical connections involve much mechanical friction. Sometimes a large hand wheel is provided for moving the contact-cylinders and as much muscle may be needed as to steer a ship. With such large currents, the ordinary series-parallel combinations result in too much burning of contacts or jerky motion of the motors, and a larger number of resistance steps are provided, with the further expedient, that after the motors have reached their half-speed condition, in series, the current is entirely shut off for a moment, the parallel connections made, and with a suitable cutting out of resistance full speed then attained.

In the locomotives recently built for the New York Central and New Haven Railroads, the multiple-unit method of control has been adopted. This means great relief to the motorman, or engineer, as he may continue to be called, and also allows two or more locomotives to be coupled together and yet operated by one man.

Four-motor equipments are common to long cars. In such cases the motors on one truck are permanently connected in parallel, and then the one pair is put in series or parallel with the other pair by the operation of an ordinary controller, though perhaps fitted with extra heavy contacts. The same cars could be used for slow inter-urban use, with the four motors in series, or for very rapid sub-urban transit by allowing the controller finally to put the four motors in parallel. Such extreme variations of speed are not often desired nor entrusted to the ordinary motorman.

It is an old idea to turn the series motors into generators to assist in stopping the cars. Of course, the direction of rotation is always wrong to allow this to take place, so a special reversing switch is needed to make the proper equivalent change in the electrical connections. The current, too, must be controlled by being led through a variable resistance.

The principal defects in the proposal consist in the fact that a series machine does not always generate until the external resistance is quite small, and when the generating once begins, altogether too much current is apt to flow. The sudden "taking-hold" of the current makes a car almost stand on end. Sometimes, too, the presence of oil or dirt on the commutators, or insufficient residual magnetism, might prevent the machines from generating at all; and further, on a grade, the car could not stop, but must maintain enough speed to keep up a certain generating action. The regular mechanical brakes are needed as reliable accessories, and in nearly every case the electrically operated brakes have proved precarious and even dangerous.

The eleventh article will consider the means of distributing electrical energy from central stations, by means of direct currents.

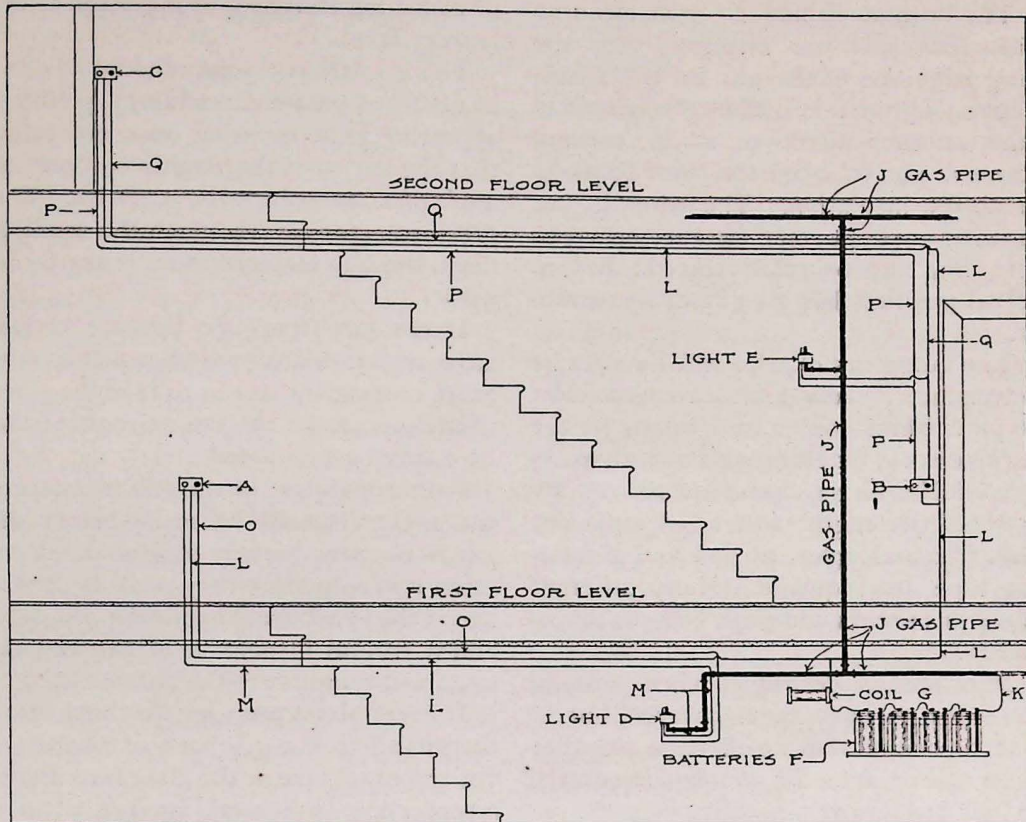
An Automatic Gas Lighting Installation

The great number of fires which have been caused by the carelessness with which matches have been discarded is an appeal for the lighting of our gas by some other method. We illustrate the manner, by the courtesy of *Shoppell's*, in which a complete electric gas lighting plant can be installed for the lighting of one fixture, to be operated from two floor levels, with one push button on the ground floor, by which on entering the hall and staircase may be lighted, and another at the top of the stairs, whence the light may be extinguished, and vice versa. A light is also located in the cellar which can be lighted and shut off from the first floor level, so that sufficient light is given for ascending and descending the cellar stairs, usually dark even in the daytime.

Electricity causes a spark. This spark

is passed over the outflowing gas, thereby lighting it. It must of course be of proper character and sufficient strength to do this. There are many ways of creating this spark, but we will speak of one only, the induction coil operated by a battery. The kind of battery best suited for our work is that made for intermittent use and called the open circuit cell.

The diagram is a sectional view drawn to represent the upper part of the cellar height with the cellar stairs shown starting down, the full height of the first floor with a full flight of stairs and the lower part of the second story level. The push buttons are marked A, B, C, A being the only push button to ignite or shut off the cellar light D. B is the push button on the first floor and will either ignite or



SYSTEM OF WIRING FOR AUTOMATIC GAS LIGHTING.

put out the light E, and push button C will also ignite or shut off the light E.

The batteries are marked F, and the coil is marked G. The gas piping is marked J, and the wiring to ground or gas pipe is marked K; while the wiring returning to coil is marked L. The wiring to light D is marked M and the shut-off O. The wiring to light E is marked P, and the shut-off for E light is marked Q.

The different parts of this lighting system may be readily traced by the letters as explained. Each wire should be traced out from its start to its finish, and if desiring to install such an apparatus, a diagram locating where each fixture is and where wiring is to be run will insure the ordering of the exact quantity of material necessary before work is begun.

There should be at least four to six cells, and they should show not less than five amperes on short circuit.

We show one wire marked K connected to the gas piping as a ground, the circuit being completed by the burners being attached to the gas pipe. The pipe and burners, however, must have no insulation whatever either in the bushing of the fixtures or along the pipe itself. We show wiring for automatic burners with two electro-magnets; and two wires are run from burner to push button, one to the white button and the other to the black button of the push plate. The white button in each case is to light the gas and the black one to extinguish it.

Contacts at the burners and the push buttons should be perfect, and all wiring should be thoroughly insulated.

The burners should be kept clean so that they will not interfere with the proper ignition of the gas by the spark. Care should be taken when the wire is to take another direction, as in turning corners, not to bend the wire so as to break the insulation. The wires in our drawing are kept some distance apart, so that they may be easily traced; but in actual practice they may be close together.

The quantities of wire will have to be determined by actual measurement. No. 16 patent finish office wire will do for the regular work, together with a small quantity of No. 24 gas fixture wire. A 10-inch coil (in length) will be of sufficient size. Some staples, tin foil and insulating tape are requisite. Many different types of burners and push buttons are to be had.

It is always desirable, when running the wires, to have them covered, but in such a position that no damage to other work will be done if it is found necessary to look at them at any time.

The batteries need not necessarily be located on a shelf, as shown in our drawing, but may be placed on the floor level; but if placed on that level they should be enclosed in a wooden box with a hinged cover and front, so that the batteries or connections can be easily repaired or replaced. The box should be painted inside and out and not be too large in size, but only sufficiently so to admit the batteries.

If it is found necessary to run wires directly across decorated surfaces, they should be purchased with light-colored insulated covering that can be color-matched to that of the walls themselves.

When driving the staples to hold the wiring in position, care should be taken not to cut into the insulation. Wires differently colored for each line can be more easily traced, and for the novice in electricity we would advise either their use

or else a tag fastened to the wires at the battery level.

The insulation at joints should be done as neatly as possible, as a lumpy, poultice-appearing joint covering does not mean that the wiring is thoroughly covered, as more often it is just the opposite. The greater neatness with which the work is done, the less material there is apt to be used.

If the gas piping or burners should have any insulated parts, another wire must necessarily be run to take the place of the piping, so that the circuit of the wire may be completed.

A thorough test of the effectiveness of the system should be made before the joints be permanently insulated. Very often it is only some very small fault that keeps the spark from operating properly, and a careful inspection of the connections will soon locate the difficulty.

If brass plates are used for the faces of the push buttons, a square of cardboard cut the exact size of the plate face will be a protection to the wall surface when it is necessary to polish these plates. When fastening plates to the walls, screws will be found more serviceable than nails.

While tungsten is considered one of the rare elements, tungsten compounds are of considerable use. Sodium tungstate is largely employed for impregnating fibers to make them fireproof. It is also used as a mordant in dyeing. Tungsten bronzes are largely employed as bronze powders and pigments. The chief consumption of tungsten in recent years has been, however, for high-speed tool steels and for hardened steel for armor plates and large guns.

An electric chafing-dish costs approximately $2\frac{1}{4}$ cents to operate for 15 minutes—considerably less than for alcohol, and all of the bother and danger eliminated.

How to Build a Quarter-Horse Power, Two-Cycle Gasoline Engine

VI. Assembling

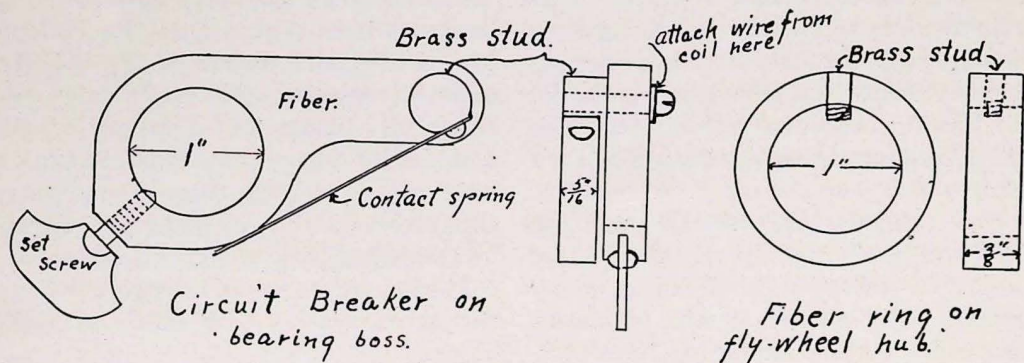
WM. C. HOUGHTON

Procure a piece of hard fibre $1\frac{5}{8}" \times 4"$ and $\frac{3}{8}"$ thick. Cut off $1\frac{5}{8}"$ of this, put in a chuck and drill and bore a 1" hole in the middle. Put on an arbor and turn the outside to $1\frac{1}{2}"$ diameter. Drill a $\frac{3}{16}"$ hole radially in one side, put the ring on the boss turned on the inside of one fly-wheel. Spot through the hole in fibre and drill a 10-24 tap hole in the boss and tap out. Take a piece of $\frac{3}{16}"$ brass rod, thread the end 10-24 and screw in. This brass stud will serve to hold the collar on the hub and at the same time make contact between the hub and the circuit-breaker spring. Saw off and turn or file flush with the fibre collar. Take the remaining piece of fibre and make a 1" hole at one end as per drawing, after laying out the outline and the hole for the spring. Saw and file the outside to shape and drill hole for the set screw to fasten it on the crank-case cover boss. This should be tapped 10-24. The screw may be an ordinary round head machine screw with a piece of sheet brass soldered in the slot to serve as a thumb-screw. The spring should be made of phosphor-bronze, but hard brass or thin steel such as a piece of clock spring will do. It should be $\frac{3}{8}"$

wide and 2" long and thick enough to be fairly stiff. The spring is screwed and soldered to the short piece of brass rod which is in turn fastened by a machine screw put through the small hole in the fibre. This screw is also used as a binding-screw to attach the wire leading from the spark-coil.

ASSEMBLING THE ENGINE

Prepare four gaskets or packings, two to go between the crank-case and covers, one between the cylinder and crank-case and one between the cylinder and head. The last should be thin asbestos paper. The others may be of very thick manila paper or asbestos, whichever is most convenient: Draw the gasket on the paper first, laying out the holes and all complete, not forgetting the hole corresponding to the transfer port. Punch the holes with a $\frac{1}{4}"$ hollow punch if one is at hand. Next cut out the large inside hole and last trim the outside, leaving it rather large and finish after the engine is assembled. Smear both sides of gaskets with graphite grease. Bicycle chain grease is very convenient for this purpose. Bolt the cylinder to the crank-case with the packing between. See



that the transfer port is clear. Next put the connecting-rod in the piston and fasten the wrist-pin in place with small set-screw. Remove the connecting-rod cap, put on the piston-rings, springing them carefully in place. Oil the piston and push it in from the top. If any difficulty is found in making the rings, enter the cylinder, tie them temporarily with wires which can be taken off as the rings enter. Oil holes should now be drilled in the bearing bosses on crank-case covers.

If it is proposed to run the engine for very long periods, these holes should be tapped for screwing in oil-cups. Bolt one cover in place with its gasket, and slip in the crank-shaft. The connecting-cap may now be fastened on, putting the screw-driver through the hole in bottom of crank-case. Slip on the other cover with gasket and bolt in place. See that the crank-shaft does not bind, though it cannot be expected to work very freely as there will be considerable friction of the piston and rings. The plug may now be screwed in the bottom using some graphite grease to make it tight. This plug is a 1" pipe plug and may be obtained of a plumber, with the other pipe fittings used in the engine.

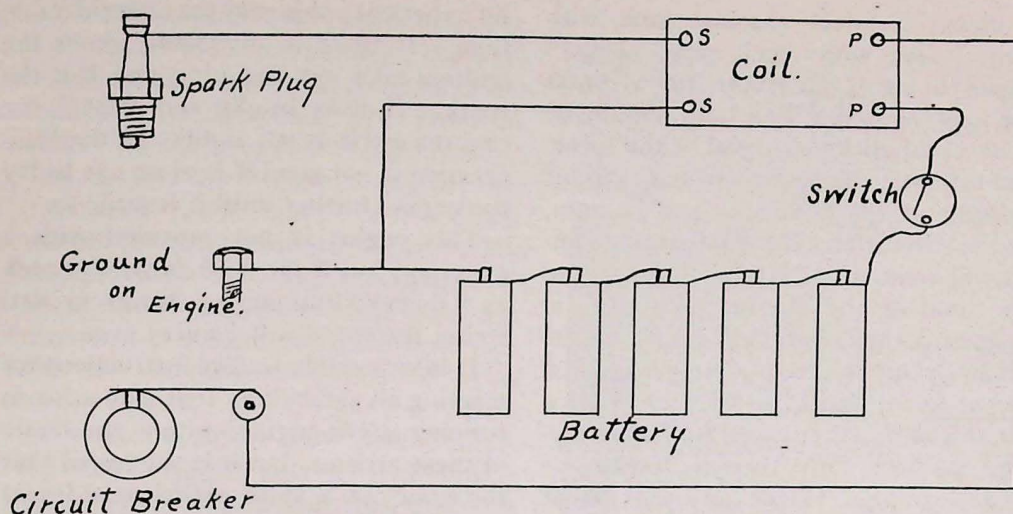
The circuit-breaker parts are next to be put in place on one fly-wheel and the corresponding bearing-boss and the fly-wheels put on and the keys driven in. It will be noticed that one end of the shaft projects beyond the fly-wheel. This is for a pulley to be used in driving slow moving machinery which it is not desirable to drive direct from the fly-wheels. No drawing is given for this, as the size will depend on the requirements of each user.

The cylinder head should next be bolted on, taking special care to have the gasket fit well and the bolts made up snugly. The gasket should of course have holes corresponding to the water-

jacket spaces, and this makes it rather slender. The amateur builder may have to try more than once before he will get one that will "stay put."

The engine is now ready for a little preliminary testing. It is of no use to proceed with the work till it has been definitely determined that the compression is good. Place the thumb tightly over the spark plug hole and turn the engine over. As the piston comes up there should be considerable resistance to the motion and the imprisoned air should push on the thumb smartly. As the piston goes down there should be considerable suction. If the compression and suction do not appear, the builder will have to investigate. It will be found that either the cylinder is not bored true and smooth or the rings are not well fitted. The crank-case suction and compression may be tested in a similar way by placing the thumb over the inlet-port, but it will not be so sharp as in the cylinder. If the engine is turned quickly a sharp inspiration should be heard when the piston passes the port on the up-stroke. If these tests show that the work is all right so far, the remaining filings may be prepared and put on. Two nipples of $\frac{3}{8}$ " gas pipe, each about $2\frac{1}{2}$ " long, are threaded at one end and turned down and slightly rounded at the other. Screw these into the water inlet and outlet. The rounded ends are for slipping on pieces of $\frac{1}{2}$ " rubber hose to connect with the water tank. It may be noted here that a hole should have been drilled and tapped in the cylinder directly opposite the water inlet and about $\frac{5}{8}$ " below it. This is for the cylinder lubricator. It should be tapped either $\frac{1}{8}$ " or $\frac{1}{4}$ " pipe thread according to the thread on the lubricator, which will be connected by a nipple and elbow.

It will now be in order to give a list of the accessories to be used with the engine.



Mixing Valve.—This should be of the smallest size, namely half-inch, and may be obtained of any dealer in gas-engine supplies. It costs \$1.75 to \$2.00. It is generally used on two-cycle engines instead of a carburetor, and costs much less. Spark-plug, which is of the usual well-known pattern and may be had of any automobile supply house. Cost about \$1.00. A spark coil may also be obtained at the same place and costs from \$4.00 to \$6.00. Second hand ones may often be obtained for less.

Five or six dry batteries, a small snap-switch and some lamp cord will also be needed, and may be obtained of any electrical supply dealer. Cost about \$2.00 or \$2.50. A gasoline tank may be improvised from a common gallon oil can. A water tank may be made of almost anything handy if it will hold about five gallons. A wooden cask, oil can, garbage bucket or small ash can will serve. Whatever is used, it must be set at or above the level of the engine and two short pipes soldered or otherwise connected with it, one at the bottom and the other near the top, but below the water-line. Connect the bottom with the lower end (inlet) of the engine jacket and the upper one with the top.

Cylinder Lubricator.—This will be of the "sight-feed" type usually put on gas engines. It is provided with a ball check valve to prevent the gas from returning. The oil holder is of glass. Cost, for the smallest size, about \$1.00. This may possibly be dispensed with if the engine crank-case is kept partly filled with oil so that the crank splashes up the oil and lubricates the cylinder. An occasional dose of oil put in the spark-plug hole will help out.

A muffler at the end of the exhaust pipe will be needed if the engine is located where the noise is objectionable. A very good one may be made where there is room by digging a hole in the ground, walling up with cobble stones and covering over with flat stones and earth, leaving a small hole for gases to get out. A cast-iron box or short section of large size pipe with numerous small outlets is also good where the hole in the ground is not practicable.

SETTING UP AND TESTING

Mount the engine on some heavy foundation. A block of stone is good, or bolt it to a heavy box of suitable size and fill the box up solid with cobble-stones and cement concrete. Screw the mixing valve in place and put on lubricators and

oil cups. Connect gasoline tank with mixing valve with small pipe. Drawn copper tubing $\frac{1}{4}$ " diameter, or $\frac{3}{8}$ " brass pipe may be used. The tank should be about a foot above the level of the valve. Connect coil, batteries, switch, circuit breaker and spark-plug as per diagram. Set the circuit-breaker so that the contact will come when the piston is at the upper end of the stroke. When all is ready, tanks and oilers full, etc., close the switch, open the gasoline valve about a quarter turn, and give the fly-wheel a sharp twist in either direction. If everything has been correctly done the engine will give a sharp "kick" and start off at a great rate. The chances are, however, about fifty to one that everything will *not* be exactly right and the engine will not go at once. The trouble is pretty sure to be caused by one of three things. Either the mixture of gas and air is not right, the ignition fails, or the compression is deficient. The first is most likely to be the case. The experimenter must patiently try with more or less gasoline until the mixture is right. If he has had

no experience this may take considerable time. If there is any doubt about the ignition take out the plug and test the spark. If it is bright and "fat" the chances are it is all right. If the compression is not good it is of no use to try the engine further until it is made so.

This engine is not provided with a governor, but if the load is steady, such as a dynamo running on lamps or batteries, the speed will be very even.

It is impossible to give instructions for meeting all difficulties that may arise in running a gas-engine, within the limits of these articles, but it is suggested that the advice of a more experienced friend be obtained in such cases, if possible. The writer may be addressed through the publishers of this magazine, in the case of any special advice being needed, and will give such assistance as he can in the limited time at his disposal.

In conclusion, the would-be builder of a gas-engine is advised to procure such books as he can and make a study of the principles and general construction of such engines.

How to Use Tools.—The Saw

C. H. CLAUDY

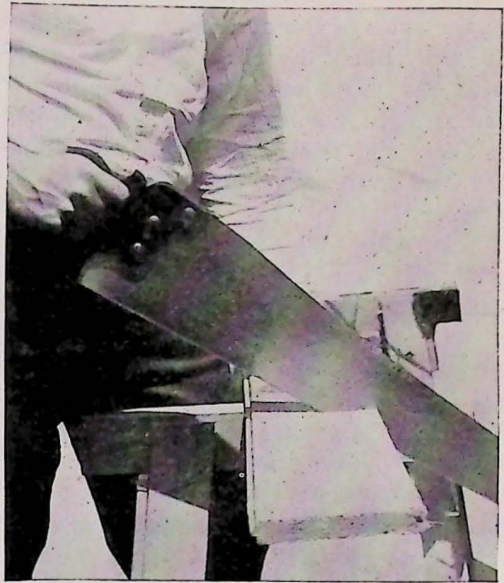
There are few, if any, things which a man can do, which he can't do in two ways, a wrong way and a right way. It is possible to do things the wrong way and arrive at the right result, but it is harder. "Form" in playing a game, as golf or tennis, "style" in playing an instrument, as the piano or violin, and "method" in using a tool or a machine, are all about the same thing—the application of effort in the most economical way to produce the greatest possible effect with the least effort.

A saw does not cut wood. It tears it.

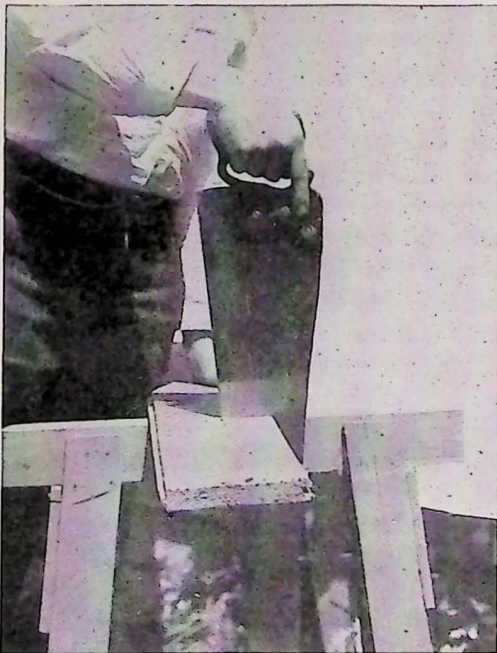
As a matter of fact, there is no cutting which is not a tearing; but we call a cut the incision or severing which is done with a tool with microscopic teeth. When the teeth are visible we call the operation sawing or filing.

In sawing, the teeth, each bent a little to one side or the other, "set" in other words, tear the wood. If you saw too fast, each tooth does not do all the work it can. Hence, sawing too fast is slow—slow sawing, besides forcing each tooth to do too much as it leaves the wood; hence, too, speedy sawing tears the bottom of the cut.

To saw a board, either rip or cross-cut, with the least amount of effort, the work should be done with the muscles of the back and shoulder and upper arm; not at all with the wrist, lower arm, or hand. The saw and the forearm should become, mechanically, one rigid piece — a piston worked by the muscles above. The angle of the saw should be constant,—about forty-five degrees being most convenient, but differing with different men, different saws, and different height of work. Another point, right here: have the work low, rather than high,—stooping over it means putting your back in it, and that means that you can saw longer and with less effort than if you depend on the arm muscles for the work. When you go to be taught to box, you learn to hit with the fist and the lower arm in a line. If you don't, you are apt to break your wrist, because the force of the blow is partly put into the angles formed by the two,—hand and arm,—and the muscles are not powerful enough to



The Right Way



The Wrong Way

withstand the shock. For the same reason the hand and arm and saw should be in one straight line; not that the force of sawing would break a wrist, but would, were the wrist bent, easily and quickly tire the wrist and arm muscles.

Never saw with the saw upright, unless it be in starting or finishing a cut. Such sawing produces a ragged cut, and by the strained position of the arm, wrist and the whole body tends to crooked work and quick fatigue. Sawing on the natural slant, on the contrary, allows a smooth cut and the least effort. The photographs illustrate the correct and the incorrect positions. In the one the body is bent to an easy, muscle-ready pose, the eye sights naturally along the saw blade, and the maximum power comes with the minimum effort. In the other, the grip is loose,—due to the finger along the side of the handle—wrong; the bent wrist and the strained position of the body preventing accurate work. A purely mechanical reason dictates a slanted saw, also; the more the saw

slants, the larger bearing surface it has on the sides of the cut, and consequently the more likely the cut is to be true with what has been already sawed. With the saw straight, the bearing surface is much smaller, and the liability to error from the true straight line consequently much greater.

Saw with the whole saw. All the teeth were made to use. Don't saw with the heel alone, nor even with the greatest pressure on the heel stroke. The pressure should be increased from the toe to the centre, and lightened from centre to heel, and the strokes should be long and smooth. Never try to saw when pulling the saw back. The teeth only grind over the wood, waste strength, get dull, and do no good.

Great pressure at any time is a mistake. The saw bites of itself into the wood with but little pressure, and the addition of more only makes it push hard without doing any more work. If the pressure be increased to the point of digging the teeth deep into the fibre of the wood, the cut will be uneven and ragged and the entire job unsatisfactory, and no time will be gained. In using the saw, as in using any other tool, the effort should be proportioned to the capacity of the tool, and the tool never hurried. Above all — and this applies to all tools with edges or teeth — the tool should be sharp. A dull saw will not work well in any position; a sharp one works well even if improperly used, but of course better when correctly handled. So with all other tools.

Electro-Plating and Gilding

V. Silvering and Wash Tinning

W. H. MOORE

It will be remembered that we were considering the simple immersion process of plating in our last number, and that we included under that head the tinning of many articles of household use. This process is called "wash tinning."

We referred also to a method of gilding by immersion, and promised a formula for the deposition of silver, or silvering of articles by simple immersion. We will take up this method first, and then return to the "wash tinning" process.

SILVERING

The most readily obtainable salts of silver are the chloride, the nitrate, the cyanide, oxide and sulphide. The double cyanide of silver and potassium has stood the test of time and experiment best, and is ordinarily used for silver plating, more particularly in the separate current process.

The nitrate may be had by adding small bits of pure grain silver gradually to a slightly warmed mixture of one part (by volume) distilled water and four parts (by volume) of c.p. (which means concentrated and pure) nitric acid. The experimenter must remember that *glass* utensils only are to be used, and he should provide himself with beakers, test tubes and such other glass vessels as he may find convenient or necessary.

Have the glass into which the silver, water and acid are introduced sufficiently large, so that the action may not cause a boiling over, and avoid breathing the gas which is given off. When the liquid ceases action on the silver (and sufficient silver must be added until this action stops), pour off the nitrate thus formed into a brown glass bottle with glass stopper, taking care not to disturb any sediment which may appear at the bottom.

In general, silver salts in solution should be protected from the light, and that is why we advise the use of a brown glass bottle.

The cyanide may be prepared by adding a solution of cyanide of potassium to one of nitrate of silver until the white precipitate (the cyanide of silver) ceases to form. This precipitate must then be collected on filter paper, washed with water, and if then dissolved in a solution of cyanide of potassium, one equivalent (or 65 parts) of the latter to one equivalent (or 134 parts) of the former, the resulting solution when evaporated will give crystals of the double cyanide of silver and potassium, above referred to. For a plating solution, dissolve these crystals in eight parts of cold and one part of boiling water.

While we give this method of obtaining the double salt, the amateur will probably find it more desirable to purchase these crystals than to endeavor to make them himself.

(CAUTION: Potassium cyanide is one of the most dangerous poisons known, and the greatest care should be exercised to keep it safely locked from irresponsible persons, and to keep it away from the mouth or breaks in the skin. The fumes should not be breathed.)

The chloride may be had by adding dilute muriatic acid or common table salt to a solution of the nitrate until the white precipitate (chloride of silver) ceases forming. Filter and wash this while on the filter paper, taking care to keep in the dark as much as possible.

With these directions for obtaining some of the more important silver salts, let us pass to several formulæ which may be used in actual silvering operations by immersion. It should be noted that best results by this method are obtained with small articles, and where a thin coating is sufficient.

A small amount of water, enough to

reduce the ingredients named in each formula to a thick paste, is to be added in each case, and the article thoroughly stirred around in the mixture and rubbed well with it, until the desired coating is obtained. The chemicals named, for which no directions for making have been given, had better be purchased at the drug-store.

1. Make a paste as directed with equal parts of chloride of silver and bitartrate of potash.

2. Use one part chloride of silver, two parts alum, eight parts common salt, and eight parts cream of tartar.

3. Chloride of silver one part, salt one and one-quarter part, prepared chalk one part, and pearl-ash three parts.

4. A fourth formula, in this case a solution into which the articles may be dipped and stirred around for best results, is as follows: To fifteen parts of either the chloride or nitrate of silver (the latter in solution) add 100 parts of the hyposulphite soda (commonly used as a fixer for photographic plates), in solution.

5. It may be more convenient to provide the following: To one part chloride of silver add 90 parts of cream tartar, 90 parts common salt and dissolve the whole in boiling water. Such a solution works best after it has been used for a time, and shows a slightly greenish tinge.

The method of using the double salt of silver and potassium under the separate current process we will take up later.

WASH TINNING

Small articles of copper or brass may be tinned by placing them between sheets of grain tin in a saturated solution of cream of tartar, the liquid meantime being kept at the boiling point. A little stannous chloride (chloride of tin) may be added to advantage.

A fine coating of tin may be had also in the following manner. In a boiling solution of the peroxide of tin in caustic

potash, place some cuttings of tin and the article to be coated in contact with the cuttings. It must be noted that the article of commerce which we call tin is not tin at all, but sheet-iron coated with tin, and cannot, of course, be used in these formulæ. Grain tin must be provided.

The method used to tin the many articles of iron or zinc which go to make up so many of our ordinary household utilities, is as follows:

One part of fused stannous chloride is

dissolved with thirty parts of ammonium alum in 2,000 parts of water. The solution is heated to boiling, and the articles immersed in it, until they have a good white color.

In every case, as we stated in another article, the object to be coated should be scrupulously clean. To this end, have a strong solution of caustic potash at hand. Wash or brush well with this and then rinse the article in clean running water. Care should be taken not to get the potash on the hands or clothes.

The Amateur's Workshop

How to Make an Annunciator (Concluded)

T. E. O'DONNELL

As it is supposed the amateur has a fairly good knowledge of the construction and working principles of the common electric bell, no data will be given in this article for making one to use with the annunciator.

The bell used in this case is the ordinary 3" gong vibrating bell, which may have been used for some other work. All that is necessary to make it suitable for this apparatus, is to remove the gong and also the gong mount or post upon which the gong is fastened. If it is an iron box bell, this can be readily done by filing a notch on each side of the projecting neck of the bell mount, and breaking it off by striking it a quick blow with a hammer. This is done because the gong has to be mounted on the outside of the front of the box, while the working parts of the bell are mounted on the inside as shown in Fig. 22. This part is made to come flush with the under edge of the top strip, so that the vibrator extends through the slot, as shown, and strikes the gong. In mounting the vibrator part, the only point to be noticed is that

the free end of the vibrator does not strike the edge of the slot.

After all the parts are assembled on the inside, the top end piece, which has the working mechanism of the bell mounted on its underside, is put in place, and also the bottom end piece. Before putting this piece on, it should have a $\frac{1}{2}$ " hole bored through it to allow the lower end of the strip replacing lever to project out below the box. The top piece has four binding posts mounted upon it as shown in Fig. 22. They should be of such a type that connection can be made from the underside.

When all parts are assembled permanently, the next step is to make the necessary connections between them. By following, carefully, the diagram of connections no trouble will be had. One wire leads from one of the binding-posts on the bell, directly to one on the top of the box. This is a part of what is termed the return circuit through the annunciator. A branch of three wires lead from the other binding post of the bell, each one passing through its respective coil

and back to one of the posts on top. After the connections are made, the work should then be tested with the current from a battery. This test should be made before the parts are enclosed.

The strips across the front of the box can now be fitted on, including the index front board. This is $\frac{1}{4}$ " thick and cut to fit into its place before the moulding is put on. There should be at least $\frac{1}{4}$ " space between this board and the underside of the moulding. Three $\frac{1}{16}$ " holes are bored through the board to receive the $\frac{1}{16}$ " wire shaft connecting the inside drop piece and the indicating arrow on the outside. These are mounted before the board is fitted to its place, and of course must be carefully adjusted, so that the trip spring will engage properly

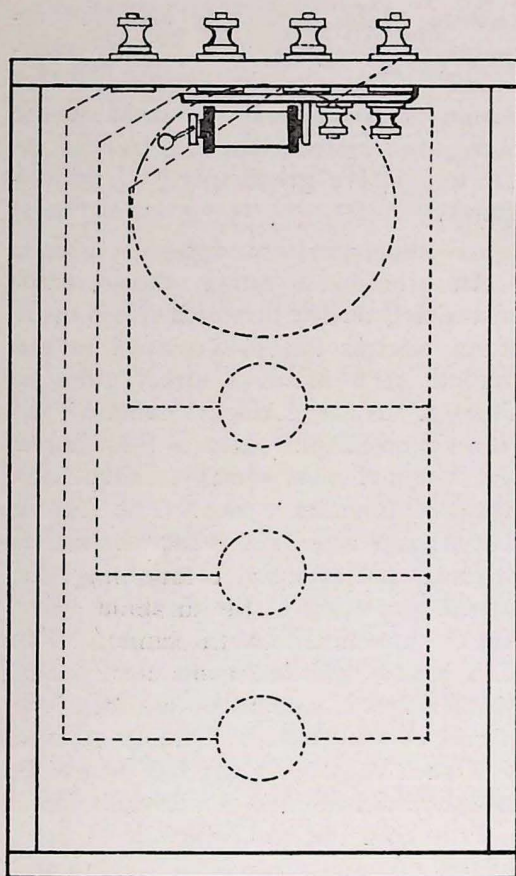


FIG 22

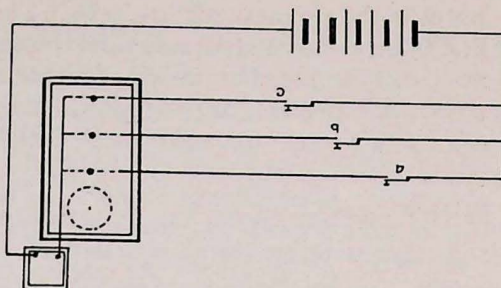


FIG. 23

with the drop piece, on the inside. The board is painted black with white or gilt numbers.

Before putting on the strips of moulding, the glass is put in over the index board. The strips serve the purpose of holding the glass in place, as well as giving the instrument an artistic appearance. The glass is not necessary to the working of the apparatus, but it protects the parts from dust and moisture. When all the strips are in place permanently, the case should be shellaced and varnished which will add further neatness and durability.

The instrument being completed the amateur may desire to put it to practical use in connection with some electric bell circuit. It should be mounted at some convenient point and where it can be seen readily without walking out of the way.

It is difficult to give a diagram that will apply to all circumstances, as the field is quite broad, but the principle of the connections is the same in all instances. Fig. 23 shows the method of connecting up the apparatus on a simple circuit or system. Each push button, a, b, and c, closes the battery circuit through the annunciator and its accompanying bell. It will be seen from the illustration that the bell is always between the battery and the annunciator proper on one side, and the push button between the battery and annunciator on the other. This method is not necessary

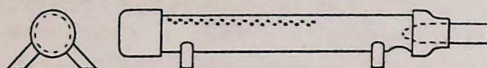
but it is the simplest rule to go by. The bell is here shown separated from the annunciator proper, but it will be understood that the two are together. It is drawn this way to make the sketch plainer.

The next article will take up the construction of a practical storage battery.

Simple Gas Stove for Work Bench

C. BROWN

The gas stove here illustrated was made by the writer in an emergency, for heating soldering irons, and found so useful as to be in use to the present day. A piece of $\frac{1}{2}$ " gas pipe, about 8" in length, is taken and one end stopped with a cap; to the other end is fitted a reducing socket, having in its smaller end a short length (about $2\frac{1}{2}$ " or 3") of $\frac{1}{4}$ " pipe, the outer end of which takes the rubber tube, the inner end being re-



A GAS STOVE FOR THE BENCH.

duced by forging to leave a small hole as indicated by the dotted lines. As close to the reducing socket as convenient, on the $\frac{1}{2}$ " pipe, an aperture is cut to admit air, while four rows of holes at the cap end allow the mixture to escape. To make the stove stand without rolling, four $\frac{1}{4}$ " diameter pins can be screwed in to form legs. A sheet-iron box made to stand on the bench retains the heat, and a bar of $\frac{3}{8}$ " round iron across the interior supports the soldering irons.

A New Design in Electric Elevators

A new and extremely simple design of electric elevator has been recently called to the attention of the public, and the new system is said to combine absolute safety, economy of power, and economy of space. In the latter partic-

ular at least it represents a great advance over the present types. All the driving mechanism in this case is bolted to the under side of the car platform, and consists entirely of a horizontal drum revolved by an electric motor. On the periphery of the drum is fitted a spiral track, which engages and travels in two series of rollers set in the guide posts supporting the car. The motor being started, the drum revolves, and the car ascends or descends as desired. As to its economy, this system has the advantage enjoyed by all electrically driven machinery, in that it consumes power only when in actual use; and another recommendation is that all the machinery being contained in the elevator shaft, much valuable floor space is saved. It is claimed to be absolutely safe, and requires no safety devices of any character. The electric elevator of this design is particularly valuable where there is an intermittent demand for its use and where great speed is not required.

An attention-arresting show-window advertising device in which use is made of an electric fan, is displayed in the window of a Madison street store in Chicago. A large black "cannon" occupies a prominent place in the window and a round shot seems to have been just fired from its mouth. The feature that attracts attention is that the ball is evidently not attached to anything, but is held oscillating in the air about three feet from the muzzle of the cannon. The trick is accomplished by an electric fan, which drives a column of air from the muzzle of the cannon. The air column is of such shape that the ball is held in its centre and there is a sufficient force of air to hold the ball, which is of light inflated material, away from the gun and continuously in the air.

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EDITORIALS

Last month we asked our readers to tell us what kind of articles they would like to see in this magazine. Because we wanted to get a lot of letters we offered some prizes. The result was entirely successful. We got the answers, more than we expected, and far more than the 200 we required before the largest prizes should be awarded. So we take great pleasure in submitting the list of those to whom the prizes have been awarded. The first prize is five dollars worth of books, the second prizes 50-cent books and the third prizes 25-cent books. If the winners will send us their choice from the books we advertised, we will forward the prizes promptly. The prize winners are as follows :

FIRST PRIZE : V. Glyde Katzenstein.

SECOND PRIZES : Fred Banker, Wray Banks, Paul G. Cochran, Edgar Welden, Oliver M. Jones.

THIRD PRIZES : C. O. Babin, E. L. Baker, Fred Bergami, Paul H. Brumfield, Claude Carlstrom, Aaron Chadbourn, Philip M. Eames, Harry N. Fries, Andrew Hafner, Herman Kraeft, Jr., Robt. J. McNally, Sterling W. Mudge, Frank D. Peltier, J. Thomas Rhamstine, Chas. E. Ries, Frank P. Rohrer, Rogers D. Rush, Albert D. Sanial, R. Norman Stephens, Harrie Taylor.

For several reasons we have decided not to publish at present the list of articles which are most desired by our readers. We are making arrangements for articles on all the most popular subjects for early publication. Two of them will be started in the May number, another in June, and others as soon as they can be obtained.

Besides the 31 subjects which we suggested, over a hundred others were named by readers. Of course we cannot furnish all these at once. Some would be of little general interest, others call for information held as trade secrets, but we shall constantly refer to this list and give articles on these subjects as soon as possible.

In conclusion, we wish to thank all our readers who sent us lists, and assure them that whether they got a prize or not, they have helped themselves by letting us know what they want.

We are going to furnish our readers with the kind of articles they want, and we are going to get them from the best writers we can find. This makes the magazine cost us more than we get at the present price of 50 cents a year. Therefore we are considering raising the price to 10 cents a copy or \$1.00 a year. The natural time to do this would be in July, when the new volume commences.

Whether to do it then or later, is not yet decided, but it will come soon. So when you are renewing your subscription, if it expires this month, decide to send \$1.25 for three years. You will get it for the full time, even if the price is put up later.

We want our readers to have confidence in the magazine and its advertisers. Therefore we request that any reader who does not get full satisfaction from any advertiser shall report it to us. If the advertiser is at fault we will exclude him from our columns.

All subscriptions stop with the last number paid for. No copies are sent after that unless the subscription is renewed. So those subscribers whose time is up with this number are requested to renew promptly. Send us a money order or express order for 50 cents for one year, or \$1.25 for three years. Coin or one-cent stamps will be taken, but are sent at the subscriber's risk. Coin is very likely to be lost or stolen in the mail. If you want any one of our 25-cent books, send 60 cents and get the book and a year's subscription.

You certainly want to have the magazine for the next year. We are going to have practical articles, just the kind to teach you, on all kinds of electrical and mechanical subjects. We want you to profit by them. So renew your subscription at once. Send the money today.

When you get this number, show it to your friends who are interested in electricity or tool-work and ask them to subscribe. You will find it easy to get them to do so. Send us 50 cents for each new subscriber, and we will give you any one of our 25 cents books as a commission. But to get this you must not offer any premium to your friend. He must pay

the full price. Just try it and see how easily you can get half a dozen subscriptions and that number of books for your library.

We want our readers to help us out with practical notes. If you have some new way of doing something, some practical device to make work easy, let us have it. If it needs a drawing, send a rough sketch if you can't make a good one. We will publish what seems useful and send you something to pay you for helping us. But we want something useful and practical, not directions for making toys or copies of what you have read in some book. The little article we publish on a gas stove is a good sample of what we want.

We have received from J. M. Marston & Co., 203 Ruggles St., Boston, Mass., a copy of their latest catalogue of circular and band saws. These machines are manufactured under patent and embody all the points of practical value in such machinery. They are made in various styles, so as to be operated either by hand or power. They are valuable and efficient aids for every one who has occasion to use a saw, — the carpenter, the cabinet maker, the amateur craftsman, or the farmer who wishes to rapidly and easily saw up his cordwood. No farm or shop can afford to be without these practical machines at the low price at which they are sold. A catalogue will be sent on request to any reader of *ELECTRICIAN AND MECHANIC* who will mention the magazine.

Acetylene headlights for locomotives are growing in favor, and are already in use on several roads.—*Popular Mechanics*.

An electric teakettle costs to operate for 15 minutes two cents.

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.]

Definition of Cycle

184. R. K. B., Spokane, Wash.: (1) Has a "Midget" dynamo, and wishes to know if it can be used also as a motor, taking current from two sal-ammoniac cells. (2) What is there inside the porous cup of such a battery? (3) What is meant by a "cycle?"

Ans. (1) You do not need to rewind the machine,—that would not increase its power, but you must put more energy into it. Two sal-ammoniac cells do not supply much power,—only enough to wiggle a door bell. You should make three or four bichromate of potash cells, each having two zincs and three carbons, each 4" x 6". The operation of a motor from batteries is rather precarious and expensive. (2) Granulated carbon and peroxide of manganese. (3) In making one revolution under the influence of a two pole field magnet a given conductor cuts the lines of force twice,—once under the north pole, and experiencing an induction of electromotive force in one direction, and once under the south pole, with the induction in the other direction. Continued rotation would merely repeat these stops or "cycles." In the case of a two-pole field magnet, the number of cycles is the same as the number of revolutions; in a multipolar field, one cycle is passed over when a given conductor passes from one pole to the same position under the next similar pole. Cycles are generally estimated as the number per second, and in general the number of cycles, or the "frequency," equals the number of pairs of poles times the number of revolutions per second. For instance the Niagara generators have 12 poles and revolve at 250 rev. per minute.

The cycles are therefore $250 \div 60$ times $6 = 25$. One cycle consists of two parts or alternations, one positive and one negative.

Batteries.—Gas Engine Ignition.—Coils

185. H. S. G., Greydan, La., (1) has made a battery of carbon and zinc plates immersed in a strong solution of sal-ammoniac, but it does not work. What is the trouble? (2) Which is the most economical, a jump spark, or wipe spark coil for ignition purposes? (3) Why do coil builders put a copper cap over the end of the iron core of the coil? With the cap off, the vibrator will work on less current.

Ans. (1) The cell quickly polarizes. You should surround the carbon with peroxide of manganese; but even with this precaution the cell is adapted for open circuit use only. A bichromate of potash solution will allow for the production of a larger current, but will require renewal after a few hours use. Consult "Modern Primary Batteries," sold by our publishers at 25 cents. (2) Some authorities believe that in place of a single explosion in a gas-engine cylinder, there is really a succession of explosions, and the use of the jump spark allows for the successive ignitions; although the flash spark is hotter, its activity is limited to a single effort, and if the combustion is incomplete, good gases escape through the exhaust. Credence in this idea is sustained by the results of tests that show a smaller consumption of gasoline with the jump spark ignition than with the other. (3) We think this is merely intended as a protection from the weather, and for economy of working should be left off.

Dynamo Construction

186. H. S., Olean, N.Y., sends a page from a catalogue that shows a toy dynamo driven by a water motor. At 90 lbs. pressure of water, output is given as 25 volts, $3\frac{1}{2}$ amperes. He asks what size of wire to use for 100 volts and 10 amperes, and how many watts that would be?

Ans. The little machine gives $25 \times 3\frac{1}{2} = 87\frac{1}{2}$ watts. You ask for $100 \times 10 = 1,000$ watts, or 1 kilowatt. Therefore you need a machine that weighs about twelve times as much. Better get a copy of Watson's "How to Build a 1 K.W. Dynamo." The driving of such a machine from the city water system, would be at an extravagant cost. A direct pipe, not less than $2\frac{1}{2}$ " in dia. and a good turbine water wheel would be necessary.

Batteries

187. C. F. L., Pawtucket, R.I., asks: (1) If sal ammoniac batteries can be filled with some solution that will allow for continuous use without polarizing? (2) Where can a small second-hand engine and dynamo, say for 20 or 25 volts, be obtained?

Ans. (1) There is none; you will have to use cells of the closed circuit type, the Fuller mercury bichromate being an excellent sort. Read "Primary Batteries," to be obtained from our publishers at 25 cents. (2) Insert a note in our "Sales and Exchange" column.

Storage Battery Construction

188. W. R., Baltimore, Md., is making a storage battery of the "Warwick" type, the rectangular lead frames being $3\frac{1}{2}'' \times 4''$ in outside dimensions, and $3'' \times 3\frac{1}{2}''$ inside, the corrugated and straight strips being soldered in place. (1) Would it be a gain to use a perforated sheet of lead riveted to each side of plates, to help retain the filling? (2) How many amperes would be suitable for charging a cell made of two positives and three negatives?

Ans. (1) Yes, but the rivets can well be placed in the central part, and the edges melted to the frame. (2) About two amperes.

Brass Casting

189. C. S., Liberty, R.I., asks: (1) If brass can be melted, on a small scale, in a cast iron kettle? (2) If a dynamo is wound for 20 to 25 volts, what changes would be necessary to get 45 volts?

Ans. (1) No, you would be likely to melt the kettle. Sand crucibles can be obtained so easily from dealers in chemicals, costing only a few cents apiece, that there is small need of trying iron dishes. Our publishers can furnish "The Brass Founder's Manual," by W. Graham, for 80 cents, postpaid. (2) Use twice as many turns of wire, three numbers smaller in the wire list,—say instead of No. 18 wire, use No. 21.

Correspondence Schools—Shocks—Drop

190. J. M., Marlboro, Mass., asks: (1) If it is possible for a person to become a competent electrical engineer by studying at home under the direction of a correspondence school? (2) Can a person receive a shock by taking hold of a single wire of an electric circuit? (3) What is meant by "drop" in a transmission line?

Ans. (1) No, but that would be a good way to begin. Then seek employment with some manufacturing company, aiming to enter the drafting or testing departments. (2) Yes, if you took hold of one of the insulated wires, for though presumably insulated, there is apt to

be a leak somewhere, and you would provide the rest of the path; if you stood on an insulated structure, like those used by trolley-wire repairers, you would be fairly free from shock. The "neutral" wire of three-wire systems is regularly grounded, and you could get no shock from that at all. (3) The number of volts lost in overcoming the resistance and reactance of the line.

Charging Storage Batteries

191. F. J. D. Jr., New York, N.Y., asks: (1) How best to charge two dissimilar sets of storage batteries? One has three cells, case being $6'' \times 5\frac{1}{2}'' \times 5''$, the other has two cells in a case $7\frac{1}{2}'' \times 5'' \times 5''$. (2) How long should these charge on a 110-volt circuit?

Ans. (1) The plates are nearly the same size, and you can readily connect the two sets in series. (2) The five cells will need about 12 volts, and the charging rate may be about 2 amperes. A rheostat or bank of incandescent lamps will be needed for controlling the current; if the latter, about six will suffice. Charge for about 8 hours.

Dynamo Construction

192. A. J. C. is building a small dynamo with Manchester type of field magnet, and a cast-iron shuttle armature, $2''$ long, $1\frac{1}{2}''$ in diameter. Field is wound with bell wire. He asks (1) What will be proper winding for armature? (2) What will be a good kind of bearings for the shaft?

Ans. (1) Bell wire has such thick insulation, that you cannot get the full measure on the spools; with regular magnet wire you would get more turns and consequently more magnetism. Use No. 22 double cotton-covered wire for armature. (2) A better way to design a dynamo is to provide the bearings first and then build the field magnet to match. You will get good ideas on this kind of a machine from the 10-cent pamphlet entitled "How to build a dynamo," signed Edward Trevert, but really written by A. E. Watson.

Converters—Insulation

193. A. D. S., Option, Pa., asks: (1) Why are rotary converters usually operated at a low frequency. (2) For alternating current transmission, which is the more economical, insulated or bare wire? (3) What is meant by "heterophase" currents?

Ans. (1) In order to comply with the demands of the direct current end of machine, the number of poles, and therefore the frequency, is limited. (2) The insulation on the wires is of very little use,—being put on largely for senti-

ment. When a transmission line is built on a private right of way, the insulation is usually omitted. Presence or absence of the cotton covering in no way affects the conducting properties of the wire. (3) Regular 2- and 3-phase apparatus has symmetry in that the several electromotive forces and currents are equal or balanced. The principle of the "split-phase" motors involves unequal forces in different circuits. A system formerly urged by the General Electric Co., called "Monocyclic," but really a decrepit 2-phase arrangement, was another example. Such departures from proper, or orthodox, practice have been sometimes jocularly designated as heterodox.

Static Electrical Machine

194. G. F., Franklin, O., asks for directions for making an electrical machine.

Ans. We suppose you mean for static electricity. The 10-cent pamphlet on "How to make a Wimshurst Electric Machine" is a good one to follow.

Shaping Mica Insulation

195. H. K. D., Jacksonville, Fla., asks if there is anything that will soften or dissolve mica, so as to make it easier to form in shape for insulating gas engine spark plugs.

Ans. No. If you wish to make conical surfaces, the shape must be formed by sticking together very thin shavings of the mica.

Induction Coil Construction

196. C. C., New York City, asks (1) Which is better for the secondary of an induction coil, single or double cotton-covered wire? (2) Where can directions be obtained for making an experimental wireless telegraph system?

Ans. (1) Use single cotton-covered, winding the coil in narrow sections, with hard rubber discs between. After every layer of wire put on two turns of paraffined paper. (2) See Collins' "Wireless Telegraph Outfit," a 25-cent pamphlet, which we will be pleased to supply.

Telephone Line Troubles

197. A. B. C., Cameron, Mont., has a party telephone line about 25 miles long. 5-bar generators are used and 1,600-ohm ringers. 21 subscribers are now connected, and more are desired. He asks (1) What is the limit in number? (2) Would 1,000-ohm ringers be better? (3) Is there such a thing as a telephonic relay that could be placed near the centre of line to strengthen the signalling current?

Ans. (1) You have rather a remarkable case now, and we would not think you could well handle the present number. You have struck

the same problem that others have encountered, and the only solution is to put in a central exchange. It would seem that yours is a legitimate subject for one of the automatic sort, say the Strowger system. (2) Higher rather than lower resistance ringers would be proper, in order that the resistance of the longest line may be small in comparison. Then all bells will ring alike. (3) No, more powerful local generators are the only recourse.

Belt Transmission of Power

198. E. N., Hartford, Wash., asks (1) If it is practicable to try to pull stumps of trees with a gasoline engine? (2) Which is better, an ordinary belt drive, or a friction drive, by crowding the rims of pulleys together?

Ans. (1) Yes, if the engine is of several horse power, and you have a very much "multiplied" tackle. (2) Use the belted drive; the area of contact of belt and pulley is then so large as to cause no serious wear or friction in the journals. Imagine the driver and the driven to be somewhat further apart than your sketch shows, and then let the third pulley be the belt-tightener. With this latter in its down position, the belt would hang loosely on the main pulleys. Of course flanges would be needed to keep the belt from slipping off when slack, but the distance between them should be at least an inch more than the width of belt, and the regular "crowning" depended upon to hold the belt central when the power is being transmitted.

Motor Construction

199. J. A. H., Attica, Ind., asks (1) If an alternating current magneto machine with a laminated core can be made to run as a motor from a battery current? (2) A small motor with a three-coil armature runs in a certain direction; how can this be reversed?

Ans. (1) If you rewind it and provide it with a commutator as described in the article in the March issue, it can be used as a motor, but of course such an armature has a bad "dead-centre." (2) Put a reversing switch between the armature and field winding as is shown in Fig. 37 in the article on "Railroad Motor Controllers" in this issue.

Storage Battery Charging—Telephone Extension

200. A Pennsylvania subscriber asks (1) If he can adapt a telephone magneto generator to the work of charging small storage batteries? (2) Could an additional telephone set be placed in a shop 500 feet away from house, and thereby save considerable travel?

Ans. (1) No, the two-segment commutator

would allow the battery to be on a momentary short-circuit, twice every revolution. Disastrous sparking would result. (2) You need merely what is called an "extension set." The local company would be very glad to supply one, (and charge rental, of course), but would seriously object to your putting it in yourself. Such sets can readily be purchased at electrical supply stores, but the presence of your outside wires would at once suggest to the inspectors what you were doing.

Dynamo Construction

201. F. W. J., Lincoln, Neb., has made a dynamo with Manchester type of field magnets, the two upright cores being 5" long, but made up of stacks of iron washers. Top and bottom castings, where the cores are attached, are 5" wide and $\frac{1}{2}$ " thick. Field bore is $4\frac{3}{16}$ " dia., axial length 3". Armature is 4" dia. and has 18 $\frac{1}{2}$ " holes. He asks (1) If he uses 2 $\frac{1}{2}$ lbs. of No. 22 wire on each core, what would be proper for the armature to allow an output of 110 volts, 7 amperes? (2) Will a one-inch spark coil work a wireless telegraph system over a distance of three miles? (3) How is carbon manufactured?

Ans. (1) Yours is an unusual and improper construction; the field cores do not need to be laminated, but you have made the layers in the wrong direction. Where you ought to have the best continuity you have a succession of breaks or imperfect magnetic contacts. In general, the design is lacking in iron, and the maximum output would be only about one-third of what you ask. A copy of Watson's "How to build a 1 K.W. dynamo," would be helpful to you. (2) We think not. Sparks for such work must be short and fat, rather than long and slender. (3) Charcoal and coke are pulverized, mixed with molasses or low grades of sugar syrup, pressed in iron moulds and baked at about 1,200° F. for twelve or more hours. The finer grades of carbon, particularly the grade required for the enclosed type of arc lamps, are largely composed of lamp-black.

Currents for Telegraph Circuits

202. W. G. M., Beaumont, Tex., asks (1) What would be the proper capacity of a dynamo to operate a telegraph line of No. 6 iron wire, 450 miles long, equipped with 12 150-ohm relays in series? (2) Could current be taken from an ordinary electric light dynamo? (3) Does it make any difference at what point along a line the main battery is located?

Ans. (1) The line resistance would be about 3,700 ohms, that of the relays 1,800 ohms, or ignoring that of the earth, about 5,500 ohms in all. The earth, however, does have actual re-

sistance, but for such small currents it is not of much account. About .03 of an ampere is sufficient to operate the relays, therefore, without any allowance for leakage or earth resistance, the necessary electromotive force would be $5,500 \times .03 = 165$ volts. A 110-volt dynamo at each end of the line ought to suffice. (2) Aside from the question of leakage, the batteries, or dynamo, could be located anywhere in the circuit. In consequence of unavoidable leakage, it is customary to put half the battery at each end of the line, rather than the whole at any one station.

Ammeter and Voltmeter

203. H. N. J., asks (1) If a voltmeter can be used as an ammeter by providing a shunt for the greater part of the current? (2) What size of spark would be necessary to enable wireless messages to be sent for a distance of one mile? (3) How many volts can be obtained if a telephone magneto is rewound for direct currents? (4) Would a toothed drum armature be better than the plain shuttle?

Ans. (1) Yes, but you would need to leave out the resistance coil, if the instrument had one. The right dimensions for the shunt would depend upon the strength of current you proposed to measure. In any case, the determination would be made by actual experiment, in comparison with some standard ammeter. (2) We do not know, please address some of our advertisers. We hope shortly to have some articles on wireless telegraphy which will give information of this kind. (3) See our article in the March issue. (4) Yes.

Field Magnets — Rheostats

204. A. E. L., Tweed, Kans., asks (1) What is the best material for the field magnet of a dynamo? (2) Why is a rheostat needed for starting a motor?

Ans. (1) Rectangular or cylindrical blocks are best made of Norway (wrought) iron, or soft (Bessemer) steel. Awkward shapes, such as are commonly needed for pole pieces cannot be forged, and must be made of cast iron or soft cast steel, — preferably the latter. (2) See Chapter VIII, in the February issue, of our Electrical Engineering Series.

Dynamo Troubles

205. L. H. W., Carlton, Minn., (1) Has made a direct current armature for a telephone magneto machine. The current will readily light several small incandescent lamps, but will not run a small toy motor. What is the reason? (2) What percentage of the energy is lost in compressing air?

Ans. The lamps furnish what is called a "non-inductive" load, that is, no magnetic field is produced in them. In the motor you have an "inductive" load, for there are various windings around masses of iron. Now, although you have adapted a commutator that directs the currents always in the same direction in the external circuit, they are very pulsating, and produce considerable self-induction. In a circuit where there is considerable of that electro-magnetic inertia, the current so lags behind the electromotive force as to be devoid of power. Our own experience with such apparatus is that the motor runs, but slowly and very feebly. (2) It depends upon the degree of the compression,—at least one-half is lost.

Alternating Currents

206. W. W. W., Cleveland, O., asks: (1) What are the proper proportions of iron and copper in an alternating current transformer? (2) What size of wires could be welded by an alternating current of 110 volts, 30 amperes? (30) What is the principle of a 3-phase alternating current motor?

Ans. (1) Primary and secondary coils have about the same weight of wire, but on account of the extra insulation, the former usually occupies more space. Weight of iron can well be three to four times that of the copper. (2) A potential of half a volt is ordinarily sufficient for electric welding, but a very large current is needed; let the secondary coil be formed of only a few turns of heavy copper ribbon. If your supply is at 110 volts and the transformer has a capacity of 5 amperes, we would suggest that you make the welding transformer of the same size, its primary being identical with the secondary of the lighting transformer, its secondary of five turns of ribbon 1" wide, $\frac{1}{8}$ " thick, or two layers $\frac{1}{16}$ " thick. A reactive, or "kicking," coil in the primary circuit will give entire control of the secondary. (3) A description of this interesting type of motor, with illustrative drawings, will soon form the subject of one of Mr. Watson's chapters on "Electrical Engineering."

Dynamo Construction

207. W. J. L., Auburn, Ont., is making a shunt dynamo, with Edison type of field magnets. Dimensions are as follows: Winding spaces $1\frac{1}{2}$ " dia. $2\frac{1}{2}$ " long; bore $3\frac{3}{16}$ " dia. $2\frac{1}{2}$ " long; magnet yoke is a block $5\frac{1}{2}$ " long, $2\frac{1}{2}$ " wide, and 1" thick,—all of cast iron. Winding is 14 layers, 80 turns per layer of No. 23 S.C.C. wire. Armature is 3" dia. $2\frac{1}{2}$ " long, laminated, and has 12 slots, $\frac{3}{16} \times \frac{5}{16}$ ", each containing 65 No. 20 S.C.C. wires. Commutator has 6 segments.

He asks if the design is good and can an output of 40 volts and 4 amperes be obtained, if speed of 2,000 rev. is used?

Ans. Yes, on the whole, the proportions are good, but a little better shape can be given to the pole pieces by carrying the "lump" down past the centre line. Also the tips of the pole pieces should be separated by a space of about an inch at the outer edges, but three-fourths of an inch in the centre. Six segments are altogether too few for 40 volts. Do not use less than 12, while 24 would be still better. You ought to be able to get the proposed output.

Eddy Currents—Magnets

208. H. J. W., Springfield, O., asks: (1) If the eddy currents in a solid iron armature core are produced by the inductive effect of the armature winding, or by the rotation in the magnetic field? (2) How can a permanent magnet be demagnetized?

Ans. (1) By the rotation in the magnetic field; with no wire at all on armature, the eddy currents would be just the same. (2) Complete removal of the magnetism can be effected only by heating the steel red hot; of course rehardening would then be necessary. Most of the magnetism can, however, be taken out by thrusting the limbs of magnet into coils through which alternating current is passing. At first the current must be strong, then gradually weakened.

Motor Construction

209. G. W. K., Hope, N.D., asks how to make a motor out of a 4-bar telephone generator?

Ans. See our article in the March issue.

Steel for Magnet Cores

210. C. E. R., Jonesboro, Ark., asks if soft steel will do in place of Norway iron for field magnet cores?

Ans. Yes. Norway iron is now somewhat indefinite in meaning, and low carbon steels are better in that their structure is more uniform.

Lamp Connections

211. W. H. B., Centreville, N.S., asks (1) If a lamp can be more economically lighted by being directly connected to the battery, than if a motor and generator are interposed? (2) Which carbon of an arc lamp should be allowed to burn the least? (3) Where can a small quantity of gold be obtained for experiments in plating?

Ans. (1) As direct as possible from the battery. Otherwise, you would lose three-quarters of the energy in the unnecessary transformations. (2) The lower one. (3) From any jeweller.

Arc Lamps

212. J. B. P., Glen Jean, W. Va., asks (1) If there are any 500-volt arc lamps made? (2) Could two 250-volt arc lamps be run in series on a 500-volt circuit?

Ans. (1) No. (2) Yes, but you could more economically operate five in series. Enclosed arc lamps require about 80 volts each. Five in series would therefore require 400 volts, and leave an ample amount to be taken up in the resistance coils that are needed for steadying the current. The mechanism must be of the "differential" sort. You will find such lamps on the market, for they are considerably used by street railway companies for illuminating pleasure grounds.

Dynamo Troubles

213. F. P. H., Baltimore, Md., (1) Has made a dynamo but it will not generate a current. It is of the $\frac{1}{8}$ h.p. size. Armature has 12 slots wound with No. 20 wire, shunt field with No. 22. With field separately excited by four dry cells, a 4-volt lamp can be lighted with the current from the armature. As a shunt motor it will run on two dry cells, but connected as a series motor it will not run at all. What is the trouble? (2) Is the principal advantage of multipolar machines over bipolar that the armature speed is less? (3) Can iron wire be used instead of German silver in an electric heater?

Ans. (1) Your evidence is a little contradictory, and we fear you have not made rigorous tests. If the machine will run on as meager a current as comes from two dry cells, we see no reason why it will not generate. In which direction did you drive it? It must be in the *same* direction as that in which it runs as a shunt motor. See if you can try the machine as a motor with a good current on someone's 110-volt lighting circuit; not directly across the mains of course, but in series with a group of lamps. A good way is to get a disused Edison fuse plug; solder lamp cord to the places ordinarily occupied by the fuse, attach the other ends to the motor. Screw this fixture in place of one of the regular fuses, turn on more or less lamps, and see what happens. (2) Yes, but in addition there is an actual saving in weight and cost. (3) Yes, for low degrees of heat; if more than 600° F. is desired, pure nickel wire is even preferable to German silver.

Dynamo Construction

214. R. S. M., Del Rio, Tex., asks (1) How many candle power will the 40-watt magneto-generator give, described in the March number?

(2) Should silk-covered wire be used? (3) How would you fix a generator that was series wound?

Ans. (1) 10 candle power, but you will understand that the solid cast iron armature will heat very fast, and the machine is adapted for intermittent use only. (2) Cotton covered, either single or double. (3) We do not know in what respect it needs "fixing." If you wish a machine suitable for running incandescent lamps or charging storage batteries, the field winding should be changed to the shunt sort.

Dynamo Troubles

215. O. C., Lewiston, Me., asks (1) What is the trouble with his $\frac{1}{8}$ h.p. dynamo? It will not generate, and if current from a battery is sent through the field coils, the ends of the shaft become magnetised. (2) Will the $\frac{1}{4}$ h.p. gasoline engine run a 10" screw cutting lathe?

Ans. (1) The field coils are wrongly connected. In going from one spool to the other, the path must be S-shaped; reverse the ends of one of the coils.

Telephone Generator

216. E. T. J. asks (1) How much power would be obtained from a water-wheel supplied through a pipe 1 ft. in diameter, 100 ft. long, under 40-ft. head? (2) What is the size of wire sent? (3) What would constitute a proper winding for electro-magnets for a telephone generator?

Ans. (1) About 10 h.p. (2) No. 34. (3) We do not know the potential of supply you would utilize for the purpose, so are unable to judge. In order to be self-exciting, you would need two separate windings on armature, one of relatively coarse wire, and connected to a commutator, the other of fine wire, delivering alternating current.

Electric Batteries

217. R. W. B., Basehor, Kans., asks (1) If it is practicable to run a forge and post drill by an electric motor supplied with energy from primary batteries? (2) What sort of batteries should be used for a burglar alarm? (3) Will an entirely metallic circuit be necessary?

Ans. (1) No, better use a gasoline engine. (2) Gravity cells for the closed circuit, dry or Leclanche for the local bell circuit. During the daytime, when main circuit is regularly open, the batteries should still be allowed to maintain a small current through some high resistance, say a 50-volt incandescent lamp; without this precaution, the two solutions will mix. (3) Unless you can use gas or water pipes, a complete metallic circuit would be desirable.

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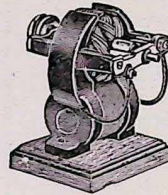
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