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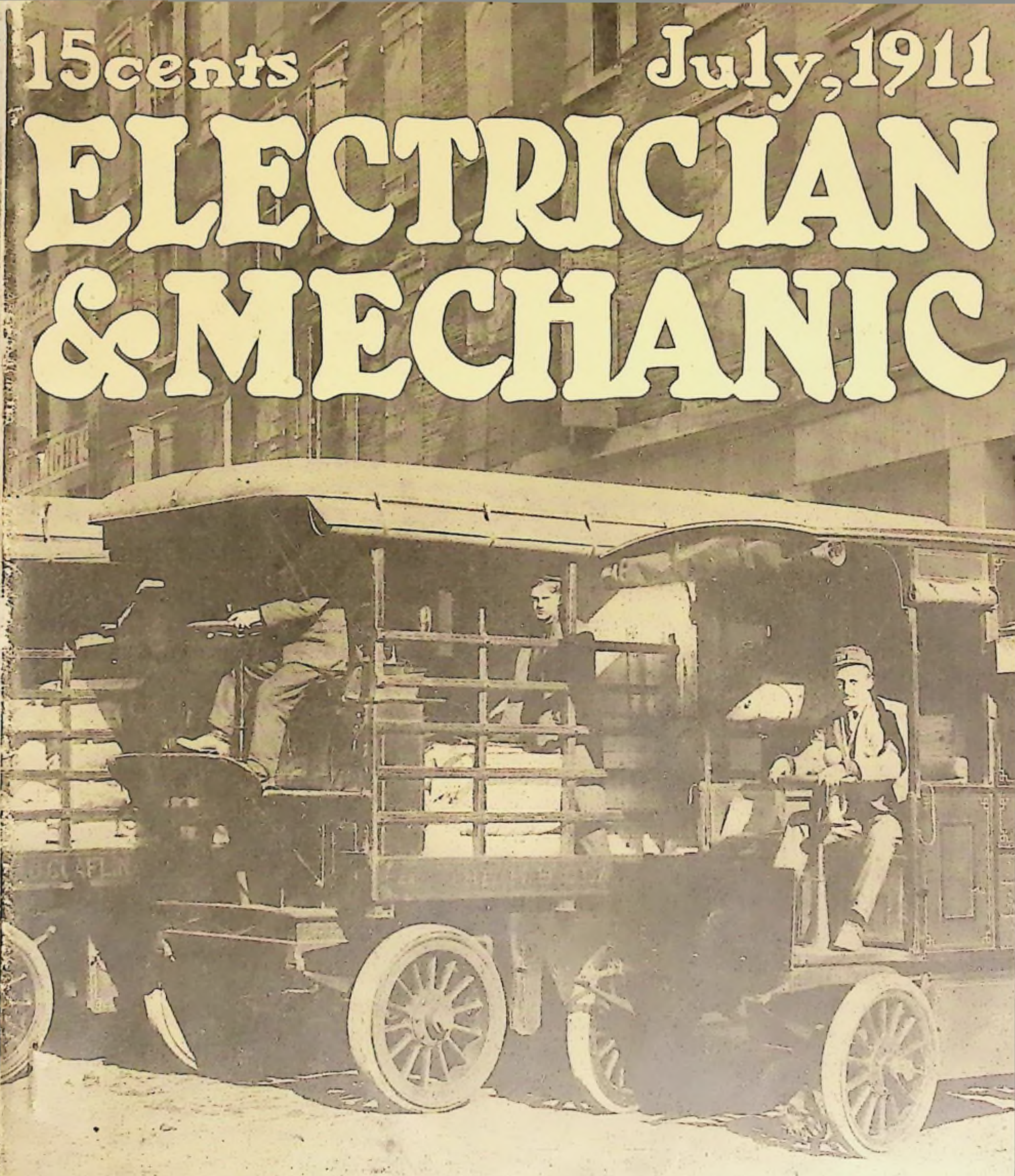
July, 1911

ELECTRICIAN & MECHANIC



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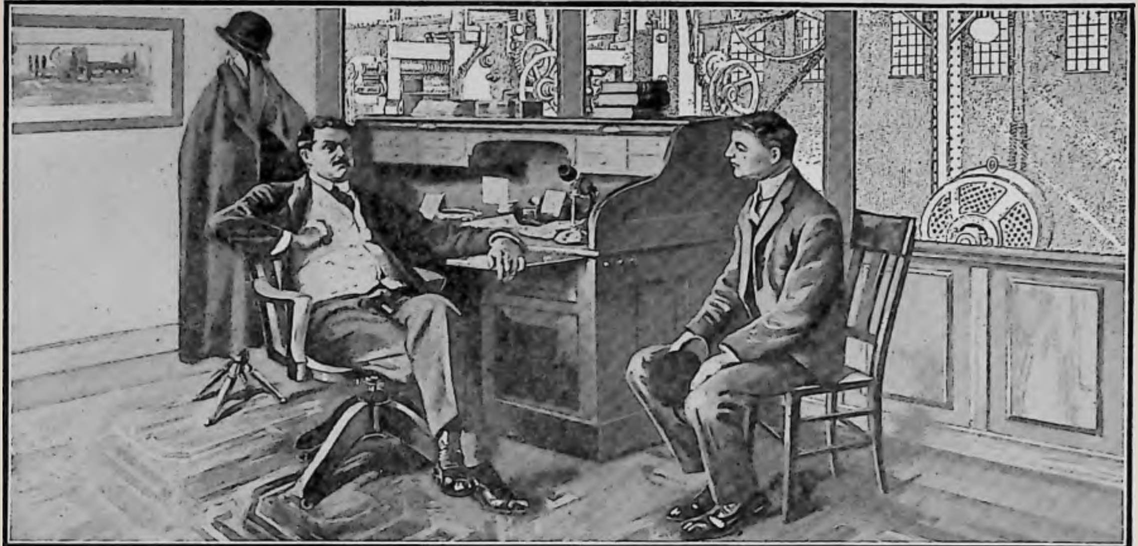

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ELECTRICIAN & MECHANIC

VOLUME XXIII JULY, 1911 NUMBER 1

STORAGE BATTERIES

Their Construction and Control

A. E. WATSON

The origin of these storehouses of electrical energy is commonly ascribed to Gaston Planté. It is true that as early as 1859 he made the first constructions that may be regarded as fundamental and perhaps permanent. That the principle was not original with him, however, is admitted in his own words, for he says of Sinsteden (1854), "In a memoir on the effects of a magneto electric apparatus, Sinsteden, having caused the current of the apparatus incidentally to act on voltameters having plates of lead, silver and nickel, obtained with these metals secondary currents sufficiently intense to bring metallic wires to incandescence."

Evidence is found of the still earlier discovery of the production of secondary currents, by Gautherot, in 1801. Other scientists of the early part of the last century are credited with independently discovering the same principle. Viewed in the light of modern experience, it may be that most of these cases can trace their concept to the idea of substituting some ordinary metal for the expensive platinum as electrodes for the electrolysis of water. It is now a regular device to improve the conductivity of the water in a voltameter (not voltmeter), by adding sulphuric acid, so it is thereby seen that at once all the materials for an ordinary storage cell are present.

In 1860, and for a number of years following, Planté made laboratory elements by rolling into a spiral two long and broad sheets of lead, separated from one another by coarse canvas, the whole being immersed in a jar containing water with 10 per cent. sulphuric acid. In 1872 he changed the method of separating the plates by substituting strips of soft rubber for the cloth. It had been found that a stronger solution gave better electrical action, but was ruinous to the cotton fabric. Fig. 1 shows the later construction. He next used parallel plates, separated by glass rods, quite in keeping with modern practice.

With the knowledge at hand that by the action of the electric current the lead plates would receive and retain a chemical change, and that by providing a circuit the chemical change would be undone, it was only a matter of lack of means and experience to make the storage battery of practical value. With Planté the means of preparing the plates, or "forming" them, as it is now called, was by the action of primary batteries,—usually Bunsen cells. At first the chemical change in the plates is of infinitesimal thinness, and even after long use, of scarcely measurable dimensions. Only by repeated charges and discharges in reversed directions, extending over months of time, and with con-

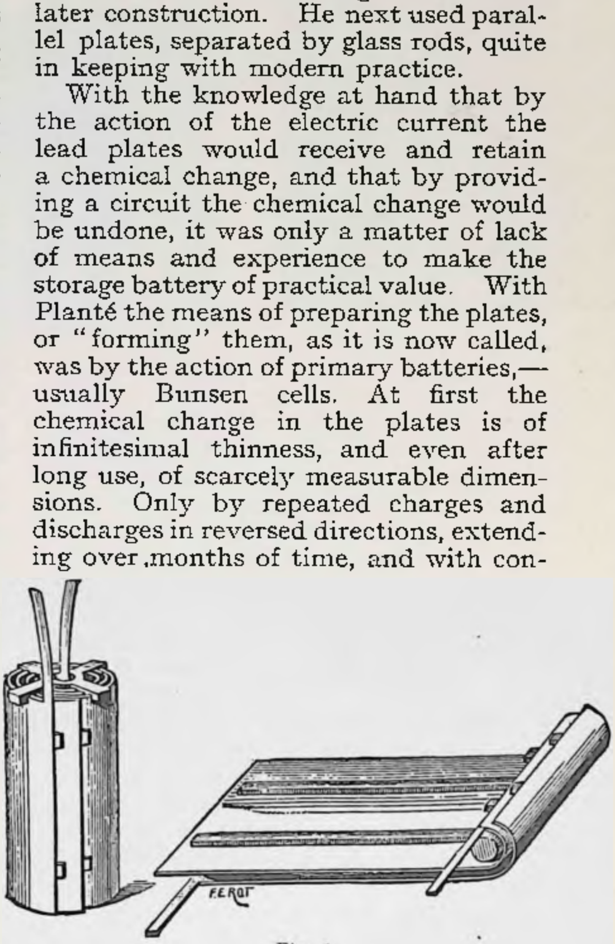


Fig. 1

siderable cost, was it possible to get a cell of reasonable capacity. Yet with numerous cells formed in this manner, Planté was able to perform laboratory experiments of classic fame. He would charge a number of relatively large cells in series, then discharge them with almost explosive violence through rods or wires that would at once be deflagrated with the intense heat; or he would charge a large number of small cells in parallel and discharge them in series, the available high electromotive force producing effects hitherto demonstrated only with static apparatus.

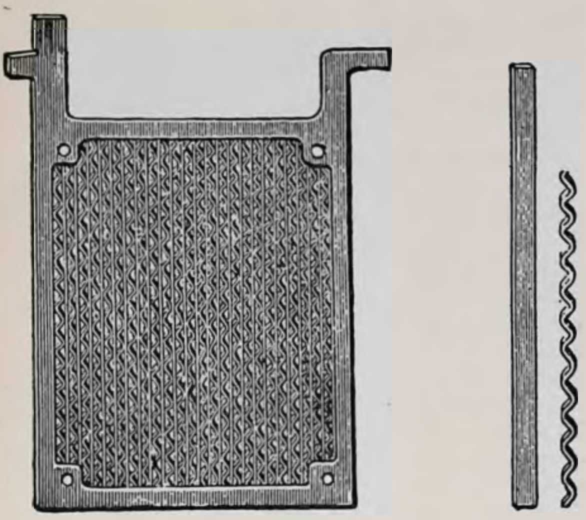


Fig. 2

By the theory of the chemical action and by the appearance of the plates, a chemist recognizes the "active materials" as per-oxide of lead and lead in a slushy or spongy state. At the start, when the elements are new, they are, of course, of the same color, but with the passage of the current, the one by which the current enters,—now denoted as the positive,—becomes black in consequence of its acquiring a coat of the black peroxide. The other retains the ordinary natural lead color. There is really an intermediate change, and some authorities believe in several. At any rate, the inevitable result of putting the sheets in the dilute acid is to give them both a coating of lead sulphate. As this is insoluble in the solution, it serves to prevent further action. When the electric current passes, however, the result is the reduction of the sulphate to peroxide at the positive and the formation of metallic lead at negative. The plates can then, as it were, receive a second coating of sulphate, and this in turn be reduced, and so on indefinitely, or until the deposits are so thick as to prevent further formation of the sulphate. Chemical action, it must be recollected, acts in molecules, and measurable dimensions of the materials involved may not be readily stated. From the electro-chemical equivalent of lead the theoretical amounts of materials required for any given storage capacity can be stated, but practically the situation is so modified by the necessity of electrical conductivity and mechanical support as to exceed these amounts five to ten or more times.

With a recognition of what these ultimate materials were, and the tediousness and high cost of their production, Camille Faure (pronounced four), in France, and Chas. F. Brush, in the United States, independently devised the process of applying to the surface of the plates pastes of the common oxides of lead, by which the burden of work required of the electric current was greatly reduced, and in addition a great reduction in weight was realized. Litharge, being relatively rich in lead, was selected for the negatives, while red lead, being more highly oxidized, was applied to the plates that were to become positives. To prepare the paste the oxides were mixed with dilute sulphuric acid, in proportion of one part of acid to four parts of water. It sets quickly, much like plaster of Paris, so only small quantities at a time must be prepared.

Such an advance in the method of making storage batteries was prophesied by the pasted-plate process as to lead to the belief that the Planté formation would be forever abandoned. Although simple grid-like castings of lead were substituted for the plain sheets, it was only the test of a short time to reveal the fact that the new structure had certain inherent weaknesses or defects not found in the earlier. Warping, bending, buckling, enlargement, shedding of the active material, and even complete disintegration of entire sets of plates, began to be the common experience. More ingenious forms for the grids were devised, with the idea either to admit or prevent the distortions, and grids alloyed with antimony were tried, and are still largely used. These defects, coupled with the legal freedom to make Planté plates, while the others were protected by the Brush-Faure patents, led the competing makers to believe that even before these patents had expired, the pasted type would be discarded. It is now a notable reversion, that with the demand for light weight batteries for vehicle propulsion, the pasted plates with improved methods of construction are again bidding for popular favor. Manufacturers who have been loud in their advocacy of one type or the other now offer both.

One of the factors that was early recognized as determining the capacity of a battery was to have the area of the plates as large as possible and to have the active material porous. Experience shows that whatever may be the other defects of the positive plate, it is free from infringing this requirement, for the natural growth of the peroxide, that ultimately means complete ruin to the plate, provides porosity in a high degree. The negative plate, however, though free from such disintegration, and thus suggestive of indefinite life, suffers from a peculiar frailty in that its spongy coating is gradually reduced into the metallic lead state. In the case of pasted plates there is often an actual shrinkage from good contact with the grid, whereby instead of a mere reduction of capacity, there may be a complete loss of it.

A process for making plates with the desired degree of porosity was that originally adopted by the Electric Storage Battery Company, of Philadelphia, when it was organized, in 1888. A mixture of zinc chloride and lead chloride was used, the lead being later reduced to the sulphate and the zinc removed altogether. This removal left the active material coherent but not exactly solid. In the test of time this construction developed faults, and its use for positives was dropped, and later for negatives too. While the name "Chloride" is still retained as a trademark, its original significance has quite disappeared.

Even when the defects from which the positives suffered in the way of buckling and warping were removed or allowed for, there remained another serious frailty, and this was the constant shedding or scaling off of the active material. With the original construction of having the plates stand in the jars, even though they were raised from the bottom by ledges of glass, the collection of metallic sediment soon reached to the plates themselves, and permitted

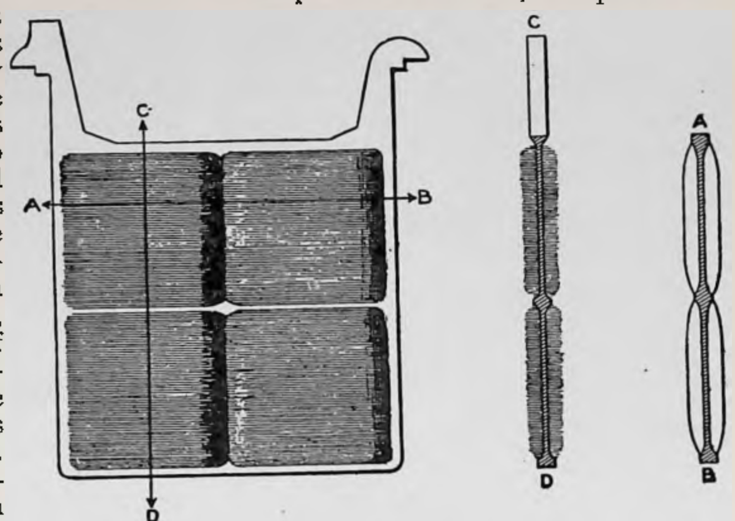


Fig. 3

a constant short-circuiting. While this reduction in bulk of the plate means its ultimate, and, perhaps, untimely destruction, relief is now commonly found in supporting the plates of all stationary types from the tops of the jars. The grid and plate shown in Figs. 2 and 3 are seen to have lugs at the tops for being supported in this manner. Even in the case of relatively small cells, a space of several inches may be provided at the bottom, as is seen in Fig. 4.

The construction represented in Fig. 2 has been used by many experimenters. It is still an acceptable design for amateurs or those desiring to make but a few plates. The pattern for the frame is easily made, say ¼ in. thick, and the castings can be of pure lead or with an addition of 5 per cent. of antimony. Strips of alternately straight and corrugated lead are inserted and soldered, but preferably "burned" in place. The pasting can be accomplished with the aid of a wooden ladle on a pane of glass. The corner holes are for driving in short hard rubber plugs, protruding long enough to serve as separators.

In Fig. 3 is represented a typical "soft lead" plate, that is, without antimony. It is of the well-known Gould manufacture, its surface being deeply rutted by revolving tools that raise the metal in thin walls but remove none of it. The two sectional views give a clearer idea. The same process is used for making both positives and negatives, but the latter does not have as many stiffening ribs as the other. The formation is by the Planté process. The "Tudor" plate, made both in this country and Germany, is of closely the same construction.

While new varieties of plates are constantly being announced, the construction with which many users are familiar, and which has been standard for a

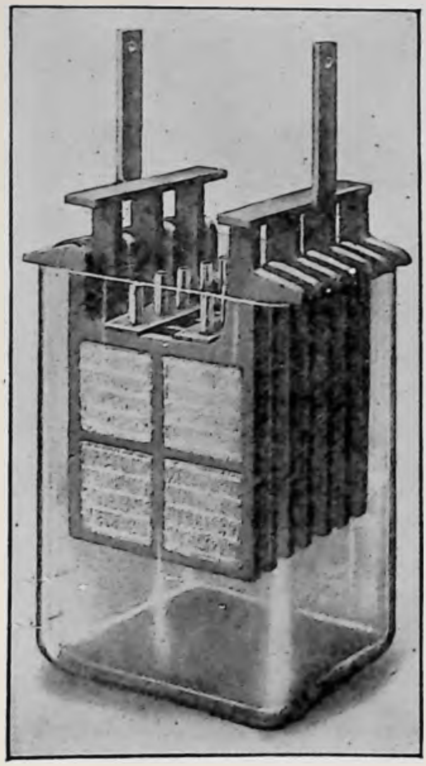


Fig. 4

number of years with the Electric Storage Battery Company, is the "Manchester" positive and the "box" negative. The former consists of an antimonious grid cast with numerous holes about 13-16 in. diameter; into these are pressed spirals of slightly corrugated pure lead. They are thus on the Planté principle. For the other a thin box is formed from sheets of perforated lead, with stiffening cross ribs, and the space between filled with paste.

Separators between the positive and negative plates have been found imperative, and while perforated hard rubber, glass rods, etc., have been used, cheapness has now made thin wooden diaphragms quite standard. In contact with concentrated acid, or combined with exposure to the air, wood quickly turns to charcoal, but completely immersed in dilute acid this carbonization is very slow, and the separators do not need renewal for years. They will not break like glass and are so porous as to offer less resistance to the passage of the electric current than the perforated rubber. In some cases, however, where a large number of plates are packed in a small space, as in vehicle batteries, both wood and rubber are of advantage. Except in the case of the simple laboratory "couples," used for calibrating voltmeters and the like, there is always one more negative plate than positive. This is to offer uniform action to both sides of every positive, as a removal of cause of warping.

A peculiarity of the electrolyte, or solution, for the lead storage battery is its particular normal strength and its variations from that under different conditions of use. Pure water is believed to be a non-conductor of electricity. The same can be said of absolute sulphuric acid,—density 1.84. Mixtures of these two liquids give varying degrees of electrical conductivity, and the particular density which seems best to fit the permanency of the battery is that at which the conductivity is the best. This is at the value of about 1.2, and results when about four parts of water and one part of acid at ordinary concentration are mixed. During charge the specific gravity rises, and is usually not carried above the 1.21 point. At ordinary limits of discharge the density may fall

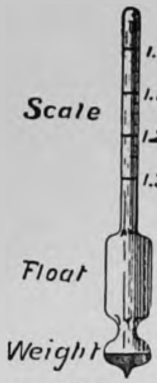


Fig. 5

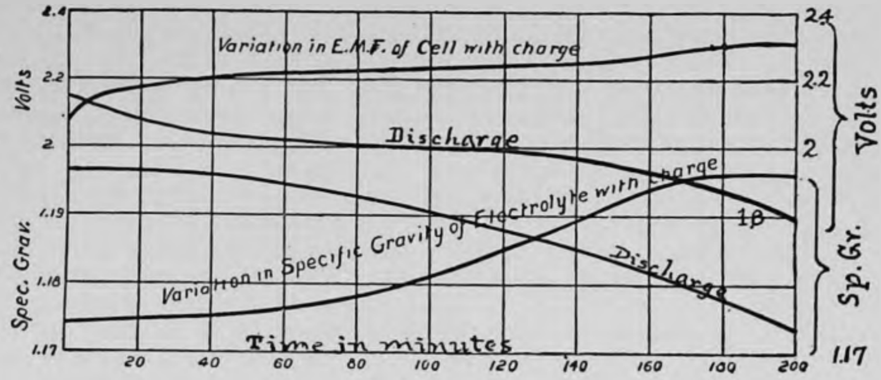


Fig. 6

to 1.15. In the case of vehicle cells, in which the quantity of electrolyte is relatively small, the figures may pass outside these limits. Stationary cells may be provided with such an excessive bulk of solution as to lie unduly within these extremes.

A device for measuring the specific gravity of liquids is called a hydrometer, the "hydro" part of the name being intended to suggest the standard of reference as being water. For liquids heavier than water the appearance of an instrument of this sort, as especially calibrated for battery use, is shown in Fig. 5. In some cases the weight in the bottom portion is mercury, but the breakage of the glass would result in dropping the mercury into the cell, with consequent damage to the plates. Lead shot make a much more appropriate filling, and their presence in the cell would clearly be of no consequence.

In central station operation a hydrometer is usually kept in a pilot cell,—not necessarily or properly the same cell all the time,—and the condition of the cell during charge and discharge regularly noted. In comparison with the allowed time of operation and with the voltmeter readings, a graphical record can be plotted, as given in Fig. 6, which to an electrician means as much as does an indicator card to a steam engineer. In consequence of limited space the plottings were made to overlap, but a little explanation will make the meaning clear. Immediately upon starting the charge, the voltage rose to slightly above the 2 point. This is shown near the upper left corner of the diagram. The charging was maintained for 200 minutes, during which time the voltage required for the process rose to 2.3, and the specific gravity of the solution that was initially at about 1.174 reached to about the 1.197 point. After waiting for a while, until the gases had disengaged themselves from the plates, and the voltage had dropped to 2.15, the discharge was begun, and was continued for 200 minutes. When this time had half-elapsed, the voltage had reached the normal value of 2, and the specific gravity stood at 1.18. At the end of the period, the voltage had reached a proper limit, 1.8, and the specific gravity was again at its lowest level.

For the construction of storage batteries manufacturers are very careful to use only chemically pure materials, and to urge that their customers shall use every effort to prevent contamination. Even silver that exists in ordinary lead is looked upon as an impurity to be removed. Pure acid and distilled water must be used for the electrolyte. Of other metals antimony alone seems to be permissible, but not more than five per cent. admixture in the grids is allowable or necessary. The reason for the caution with the materials is that such are usually dissolved by the acid, and their presence in solution results in undesired combinations with the lead. The whole secret of storage of power at all is comprised in the fact that the lead is insoluble and entirely inactive in any respect except under the action of a current of electricity. By whatever amount other materials are present that will permit chemical action, the battery will refuse to hold its charge. It is rather a marvelous spectacle, therefore, that a charged battery presents; that surfaces of the lead plates in direct contact with an acid that would soon disintegrate almost any other metal may stand inert day after day, or week after week, until the mysterious electric current provides its permitting circuit.

A lead storage battery is far from perfect, as many a user has found out at considerable expense. It is subject to diseases, the nature of which were not at first clearly understood, and their effect not realized until the battery was ruined. At the head of these troubles can be placed what is known as "over-sulphating," or commonly "sulphating." A certain amount of this action is necessary in the intermediate condition of the active materials, between the peroxide and spongy state, but an excess of sulphate means ruin, for then it is so thickly deposited, or formed, as to shield the plates—in this case the negatives—from their expected action. The sulphate is really a poor electrical conductor, and only the thinnest imaginable layer of it is ordinarily in circuit; but let this acquire an appreciable thickness, say on the visible parts of the plates or between the active material and the grid where shrinkage has provided an opportunity, and the plate is to that extent shielded from the desired action. If the covering is only partial, or uneven, then different parts of the plate are acted upon unequally, very high rates of charge and discharge forced upon small areas, with consequent warping, bulging, shedding of active material, etc. In general, if this undue sulphating is prevented, long and satisfactory life of the battery may be expected.

The principal cause of this sulphating is in letting the battery stand in a discharged condition. Even when nominally out of use, a "freshening" charge should be given every few weeks. Evaporation of the electrolyte will certainly result in ruin to the exposed portions of the plates—a case admittedly of pure negligence. Many of the troubles which users have experienced might have been avoided had the cells been placed, like any other expensive apparatus, in a light (not sunny) place, where even casual inspection would have been permitted. For stationary cells that are not worked at high rates, but where loss of electrolyte by evaporation is troublesome, some users have adopted the expedient of pouring a layer of pure paraffin oil, say ¼ in. thick, on the solution. Of course the cells should be protected from collecting dust or accidental dropping in of other foreign substances by coverings of window glass.

As to the charging or discharging rates of a battery, or its capacity in ampere hours, no exact uniformity exists between the different manufacturers. Nor is this to be expected, for with the different classes of work to be served, and the variations in the construction of the cells, it is certain that different ratings will be admitted. Ratings are ordinarily based on an 8-hour, a 5-hour and a 1-hour discharge, the latter being recognized as fitting the case of a "peak" load. The more rapid the discharge, the less will be the total output. For instance, a cell that will supply a current of 20 amperes for 8 hours would be listed as having a capacity of 160 ampere hours. The same cell, if discharged at a rate of 40 amperes, would be exhausted in three hours, or with a total of 120 ampere hours; or if at 80 amperes, in only one hour. A standard cell of this capacity has nine plates, each 7¾ in. x 7¾ in.—4 positives and 5 negatives. From these dimensions a person can readily estimate the proportions of cells of any desired capacity. A good charging rate is found by allowing 20 to 25 sq. in. of positive plate (counting both sides) for every ampere. Thus in the example given, the aggregate area would be about 500 sq. in.; therefore a good charging rate would be between 20 and 25 amperes. The discharge, too, will augur long life for the battery, if it does not exceed this rate; but for emergency service, even greater than the 1-hour rate may be encountered, and batteries may be installed as a sort of insurance against break-down accidents. For instance, a battery just put into service at one of the Edison sub-stations, in New York, has a 1-hour rating of 10,000 amperes; for a 20-minute discharge an allowance of upwards of 20,000; for 10 minutes over 32,000; and for a com-

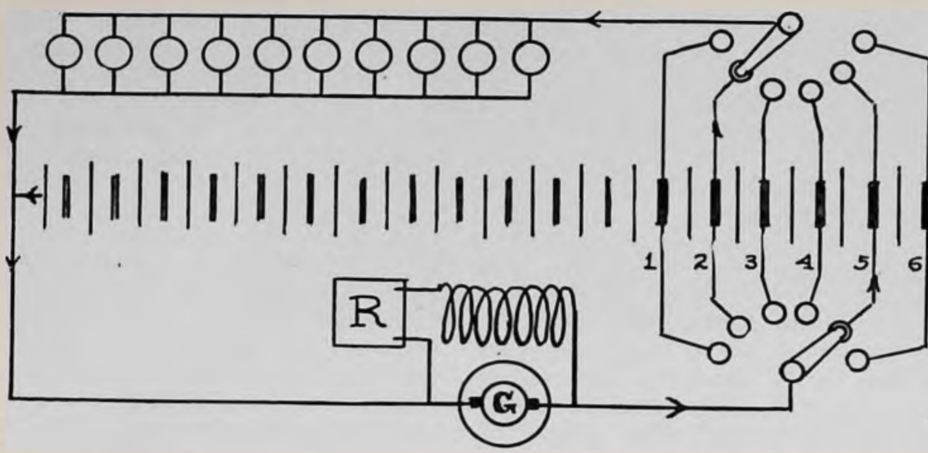


Fig. 7

plete discharge in 6 minutes, 43,000 amperes. Such a rate would keep an extensive system from complete shutdown in the event of some accident at the main generating station while new or additional generators were being started.

To describe in greater detail the construction of plates as put out by the various manufacturers, to note their special qualifications, or explain the claims of new makes constantly being announced, would clearly be outside the bounds of this article. After a brief description of some of the general features entering into the use and control of batteries, whatever be their make, some mention will be made of certain of the most recent announcements in storage battery construction.

Storage battery engineering forms a topic quite apart from the matter of the factory construction of the individual parts of the cell. Inattention to the necessity for adequate apparatus or care has too often cost the entire price of the battery. With the admission that the battery itself is an expensive adjunct to an electric lighting or power station, and subject to peculiar destructive influences, there has been a gradual acquisition of skill and auxiliary devices, which, though in some cases expensive, cannot be omitted from a modern plant.

The simplest case of engineering for a battery adjunct is that in a small or private plant, in which the generator is normally running at the potential required for the lamps, and the cells must be charged so that for certain other hours, when the load is small, the dynamo can be shut down, and the battery supply the demands. If the installation is with 110 volt apparatus, the smallest number of cells that can well be allowed, admitting a minimum of 1.8 volts per cell, will be $110 \div 1.8$, or 62, and this number can be arranged in two sets of 31 cells each. A double-pole switch is so connected as to permit these two groups being put in series or in parallel with each other. A rheostat and ammeter is placed in one of the main leads. With a maximum charging voltage of 2.5 volts per cell, there will then be 31×2.5, or 78 volts usefully employed, while the difference between this and 110 will be wasted in the rheostat. At the beginning of the discharge, when the two groups are in series, the voltage will be 124, and 14 volts wasted in the rheostat. As the voltage lowers, an attendant or watchman is expected to cut out the resistance. Of course this method is wasteful of energy, but in proportion to the size of the installation it may be no more so than the "expensive economies" found in large stations.

A second method, one that requires a minimum of skill and attention, and therefore popular for country residences, is known as the "counter-cell" control. The charging is supposed to be done with a dynamo of sufficient potential, by day, and the lights operated entirely from the battery during the greater part of the evening. The main set consists as before, of 62 cells, but all in series, and the voltage to charge them is 62 x 2.5, or 155. To allow for lighting 110 volt lamps, while the charging is going on, 45 volts would, therefore, have to be taken up by passing the current through about 20 cells connected directly counter to the main set. A dial switch has its hinge connected to the lighting circuit, and 20 wires lead from its various contacts to the connections between the individual counter cells. The other end of lighting circuit is common to the generator and end of the main battery. By occasional reference to the voltmeter when connected to the lighting circuit, such a number of counter cells are turned in or out as to give close regulation of pressure. When the generator is disconnected, most of the counter cells would be necessarily cut out, but for cases of extra load, when it might be desirable to keep the generator running, its voltage is so reduced as to admit cutting out most of these cells, and let the generator and battery work in parallel.

The qualifications of the counter-cell method of control consist in the fact that all the main cells are treated alike, therefore with reduced likelihood of experiencing weak cells, as are met with in systems designed to operate with greater economy. Further, the end cells pass current always in the direction to charge them, thus they never run down. For this reason it is common to find them consisting of plain grids, without paste or having been "formed."

In large central stations, either the "end cell" or "booster" method of control would ordinarily be found. The diagrammatic scheme of the former is shown in Fig. 7. A shunt generator is represented at *G*, its field being controlled by a rheostat as in the usual manner. The only real difference in the generator from standard construction would be, at most, in its ability to generate 150 to 160 volts. The end-cell switches are double, one being connected on the generator side, the other on the circuit to be supplied. In the positions shown, (1) current can be regarded as both charging the battery and supplying the line, there being a sufficient number of the end-cells cut in to give the right voltage for the lamps. The combinations also allow (2) the generator to supply the exterior circuit alone; (3) to charge the battery alone; (4) the battery to carry the load alone; or (5) the generator and the battery to work in parallel. There is a serious defect, however, that in the first case, as can be seen from the diagram, certain end-cells are compelled to pass the regular charging current in addition to that flowing in the line. This overcharges and undesirably disintegrates the plates.

In constructing an end-cell switch, it must be observed that the hinging or sliding arm must not be broad enough to bridge simultaneously across two cell contacts. For in the instant of transition there would be a short circuit with consequent burning, melting, or welding of the metal parts, to say nothing of injury to the cell itself. For small installations, an occasional flicker

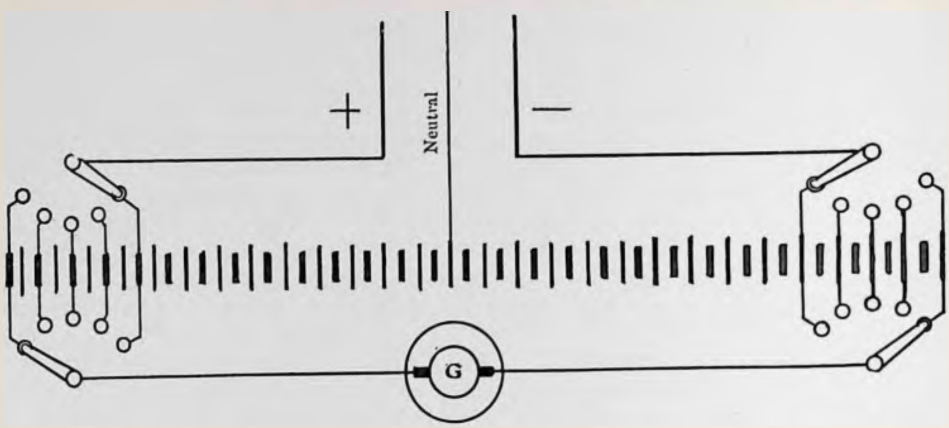


Fig.

Fig. 9

in the lamps, at the moment of exchange of contacts, is not of serious consequence. For large installations, while the flicker might be tolerated for lights alone, the interruption would be undesirable for motors, but of greater consequence would be the burning of the contacts at the point of rupture. For avoiding this, it is common to make the contacts double, with a resistance, say, of carbon blocks between. Then in the moment of transition, the carbon does not permit an open circuit for the line nor a dead short circuit for the battery.

The end-cell switch scheme can readily be extended to the case of a three-wire system, as represented in Fig. 8. Such a storage battery installation admits the desirable advantage of supplying both sides of the system from a single generator, this, of course, being of double the ordinary voltage. The middle point of the battery gives the point for attaching the neutral, and, as is common practice in extended networks of wiring, it is grounded. The first installation of this sort was in the original part of the Atlantic Ave. Station of the Boston Edison Company, 300 volt generators being employed, while the lamps are operated at about 110. The present equipments in the various sub-stations involve apparatus of the same sort. A view in a large battery room is given in Fig. 9, the portion selected being that in which the numerous copper bars, forming the end-cell connections, rise to the ceiling, thence pass to the switches in the adjoining room.

While it is possible to charge batteries during the day, in connection with the other load, it is not the ordinary custom of large central stations to select this time. Rather, it is preferred to regard this work as constituting a late night or early morning load, when the apparatus would otherwise be idle. Further, the batteries have necessarily been exhausted in the evening, and as the plates suffer by standing in a discharged state, they should be at once charged. A chart taken from an actual city station record is given in Fig. 10, and presents the 24-hour run in a graphical manner.

Before 6 o'clock the load is seen to be small, about 800 amperes, but then rises to 1,000. Between 7 and 8 o'clock shops and stores are opening, and the load has reached to nearly the 4,000 ampere mark. It remains fairly constant until noon. As motors and other electrical apparatus are shut off, the demand falls to only a little over 3,000 amperes. There is then a steady rise from 1 until 3.30, as afternoon shopping increases. The day selected is one of the shortest in winter, and darkness sets in early, and the loads bound up to the 10,000 ampere point in an hour's time. Generators sufficient to supply 4,000 amperes only are running, and the excess demand is drawn from the storage battery. The

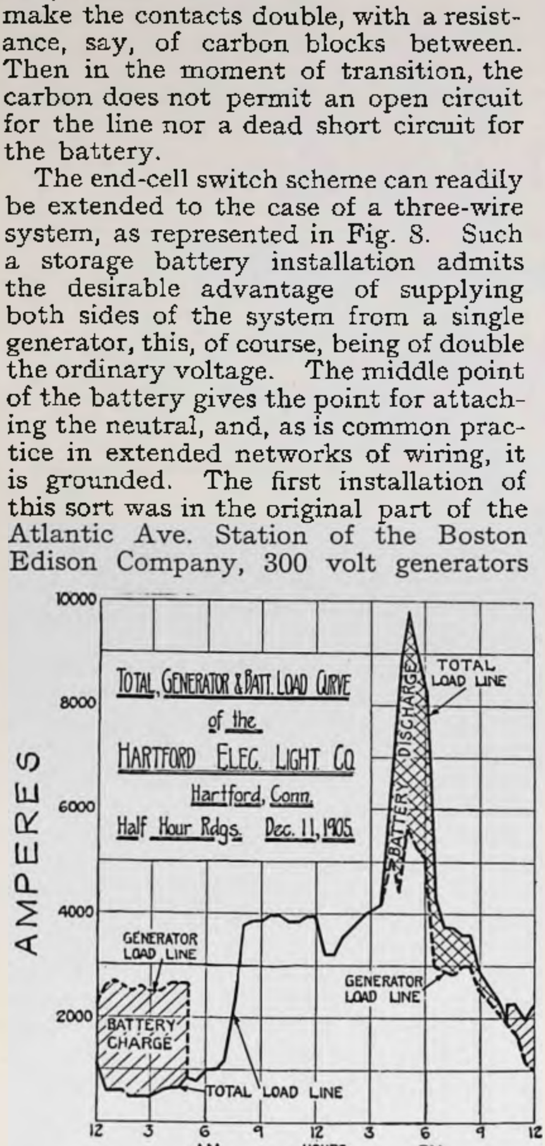


Fig. 10

load falls off quite as rapidly, and by 7 o'clock it has again reached the 4,000 ampere level, and constantly getting lower. A nearly steady load is carried until almost 9 o'clock, when wise people are getting ready for bed. By 10.30 the load is only 2,000 amperes, but the batteries are now exhausted, and the generators must recharge them. This is done at a rate of about 2,500 amperes until 5 in the morning. The charging could have been kept up for an hour longer without interfering with the day demands, but they were purposely filled in sufficient time to admit cleaning the fires and shifting from the night to the day force of men. The battery then remains inert until the next afternoon's demands arrive.

case might be, but the electric motors are more convenient and economical.

In case a storage battery is to be located at the end of a long railway feeder, where there is an admitted variation of potential of 100 to 150 volts, a series wound booster can be inserted in the feeder at the station, whereby, when the load is light at the distant point, the battery will receive a high enough voltage to admit charging, and when cars are starting, the drop in potential, due to the line resistance, will be sufficient to allow the battery to discharge, and yet hold the voltage at a higher point than would be the case if the entire current was drawn from the power house. Indeed, many installations can be found in which the

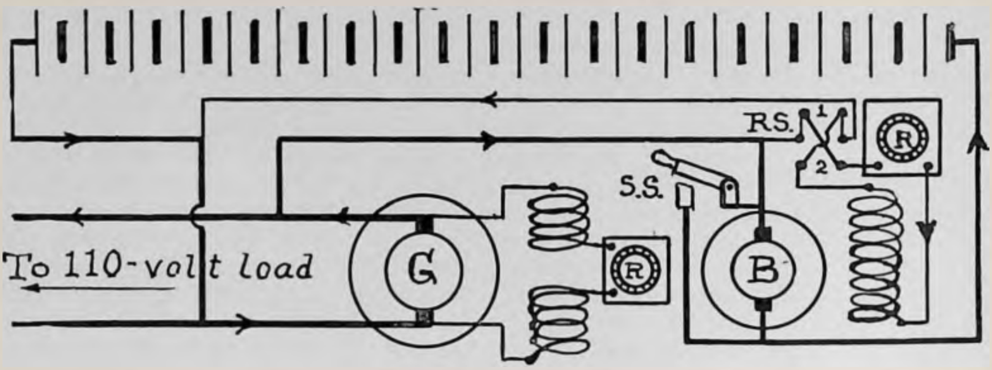


Fig. 11

A method of battery control that is preferred by some engineers for electric lighting stations, and imperative for such intermittent or extreme loads as are encountered in railway work, involves the use of "boosters." Such machines are merely generators for large currents, but of relatively low voltage. They closely resemble generators made for electrolytic processes. Several variations in the appearance of the field winding, series, shunt, compound, differential, and combinations with external regulators, are found. Some of these depend upon manual control, others, with a marvelous degree of effectiveness, are automatic.

Boosters are ordinarily driven by directly coupled motors, of either the direct or alternating current sort, taking their current from the main supply at the station. They could be driven by steam engines or water wheels, as the

variations in the voltage at the distant point are entirely relied upon for permitting the charge and discharge without the adjunct of the booster.

For reasonably steady loads, or such as may not require manual control oftener than quarter or half hourly,—for instance the sort depicted in Fig. 10,—the shunt booster would be practicable. Such a substitute would dispense with the extensive equipment of end-cell switches with their costly array of connections, therefore perhaps offset the price of the booster itself, and would further allow the desirable advantage of being able to charge and discharge all the cells alike, and to assist the battery in both of these operations.

By a shunt booster is not meant that the machine is self-exciting, for in every case boosters are separately excited, but it is meant that the field is in a shunt circuit across the main bus-bars of the switchboard. Of course a rheostat is also in circuit, to control the voltage of the booster. A reversing switch is also inserted in this field circuit, whereby the booster may generate a voltage that can be added to that of the main machines, or in the reversed position, to generate an electromotive force to help the battery to discharge. Diagram of connections of such a booster is given in Fig. 11.

In the case of a compound wound field magnet, the shunt portion would be as in the preceding case, the reversing switch being ordinarily in the position to permit the discharge of the battery. The series field winding is in the battery circuit. The adjustment of number of cells, field rheostat and series turns is such that with normal load, such as the generators can readily supply, the battery will be inert, the sum of the battery and booster voltages being just equal to that of the line. When a sudden demand for current comes, as by the starting of a number of cars, or even for such a continued demand as in case of the peak of the load, the voltage of the line will somewhat fall, the battery will discharge through the series coil of the booster, increase its magnetism in the direction to induce an electromotive force to accelerate the discharge, and thus relieve the generators.

A differentially wound booster may accomplish this regulation without demanding so great a fluctuation of the line voltage. The purpose in all these arrangements is to keep a fairly constant load on the generators, thereby permitting economical station management, and to let the fluctuations be borne by the battery. In the differential winding the series coil is divided into two parts, or rather, a tap is made near a middle point, and to this lead one of the sets of booster brushes is connected. Other brushes attach to one pole of battery. Outer terminals of series coil lead to two points in one of the main bus-bars, across which a single-pole may be closed when it is desired to short-circuit this winding. Other pole of battery is attached to other side of main line. The entire current, or that for the particular feeder to be regulated, passes through the series coil of the booster in the direction to produce discharge, while the shunt coil is acting in the opposite attempt. The result is that at ordinary or normal loads the battery neither receives nor gives a current. When further demand is made, there will immediately be an increased magnetization of the booster field; the shunt influence will be overpowered, and an electromotive force will be generated in the direction to assist the battery to discharge. When the demand on the line is less than normal, the series coil will exert correspondingly less effect, the shunt winding will be the determining factor, and the booster will generate an electromotive to assist the generators to charge the battery.

While such automatic action of boosters gives a remarkable smoothness to the generator load, it is sometimes fruitful of injury to the batteries, for the booster cannot distinguish between a rapidly released demand and one of relatively long duration. Indeed, the battery might be permitted to carry a peak load when more properly additional generators should be put into service. For different hours of the day, therefore, care must be taken in the station administration to see that the battery is not worked beyond its legitimate capacity. Failure to recognize this important point has led to many cases of destruction of the battery with an unmerited criticism of its worth.

Another method of connecting a booster is called the "constant current" case, applicable to controlling power circuits supplied from the same generator as the lights. The booster will permit and even encourage considerable variations in voltage on the power circuits, say when elevators are started, without disturbing the lights.

In the Gould "counter electromotive force" system, the series coil of a small generator is inserted in the main line, and its armature in the shunt field exciting circuit of the booster. Booster itself has no series coil, the armature and battery being merely in series across the line. In the normal case, the c.e. m.f. generator has a field just strong enough to prevent current from flowing through the booster field. This machine is therefore inert, and the battery neither charges nor discharges. A heavier demand on the line allows the little machine to generate a voltage higher than that across the line, and the polarity of the booster then will be such as to permit a discharge. With less current demanded, the voltage will be less than that of line, and polarity of booster will be reversed, and a charging current pass through its armature.

The Electric Storage Battery Company frequently equips its power installations with an rheostatic device, called its "carbon-pile" regulator. A solenoid in the main circuit, counteracted by a spring, pulls on one end of a lever. plates is in circuit. Variations of pressure between them gives, for an exceedingly small motion, a large variation of resistance. This machine, thus controlled, energizes the field magnet of the booster.

Boosters can usually be recognized by their relatively large commutators and connections. A picture of one is given in Fig. 12, which has a capacity of 1,500 amperes at 55 to 110 volts. It is directly coupled to a 230 h.p., 550 volt, 450 revolution motor. The change in the volume of the electrical energy is suggested by comparing the size of

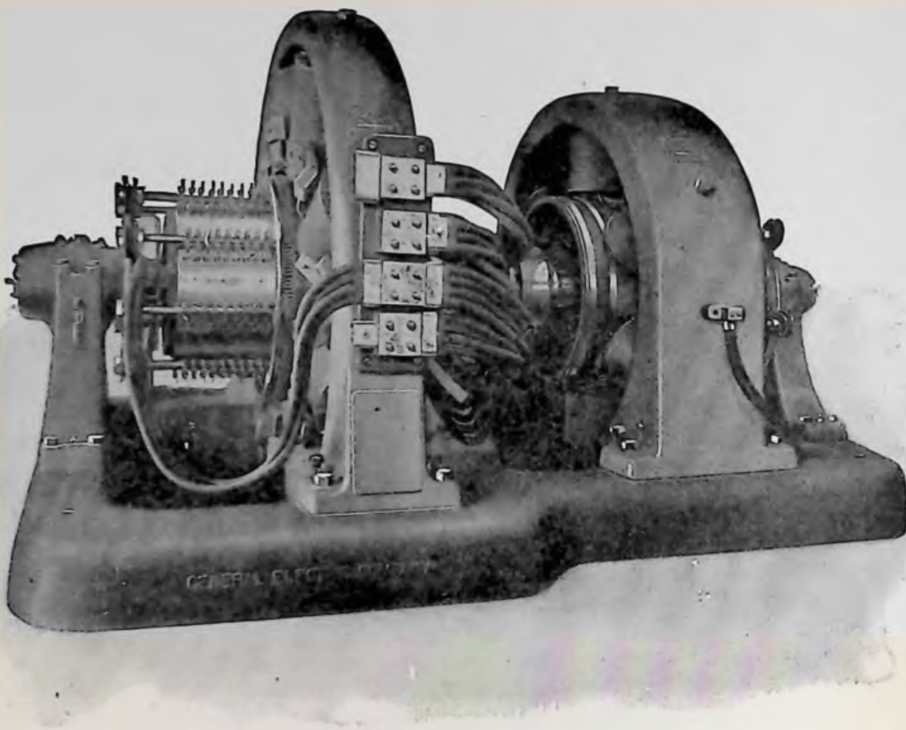


Fig. 12

This is pivoted in the middle, and by its movement one stack of carbon plates, serving as the rheostat, is compressed, the other relaxed. Terminals of the battery are led to contacts at the upper end of one or the other of these piles. A common connection between the lower ends leads to the shunt field winding of a small generator; other end of this winding is led to middle point of battery. The result is that the field of this machine is energized with current in either direction, from one half the battery, as determined by which stack of carbon the cables that connect with the brushes at the different ends of the machine. The field magnet is arranged for the differential system of excitation.

With a recognition of the beneficial effects of storage batteries in central station operation and for other stationary applications, there has of late been a new impetus given in their application to vehicular work. With an electric motor as the ideal of simplicity and efficiency, it is disquieting to have its usefulness so handicapped by the great weight and mechanical weakness of the lead battery. While Edison's improved nickel-iron-alkali cell has been welcomed with open arms, its advent has only been the more to encourage the builders of the other sorts to devise, if possible, more rugged constructions and of greater capacity.

The Electric Storage Battery Company now announces its "Iron-clad" exide, which seems to be a resuscitation of the Tommasi construction. For positives, slender, hard rubber, perforated tubes are used, in each of which a rod of antimonious lead is inserted and the remaining space filled with finely divided metallic lead. With the change of this to the peroxide the increased bulk exerts sufficient pressure to maintain the electrical contact. Negatives are like the original "Exide," only somewhat thicker. The Gould Storage Battery Company has been tempted away from its former rigid adherence to the Planté formation to making a rugged form of pasted plates, and 30 of the cars now operated on the Third Avenue Railroad Company's lines in New York City are equipped with this make. The "National," formerly known as the "Unit" accumulator, has received improvements at the hands of its new manufacturers, The United States Light and Heating Company. The Niagara Lead and Battery Company is the latest in the field, and announces its perfected "Salom" cell, in which the active materials, in their desired final condition, are put onto the antimonious grids in a manner that maintains the electrical contact. This has been the aim, but not the realization of many an early experimenter, but the claims made for this construction make it a most interesting announcement for the lead type of cells.

The Edison cell, as now offered, has so changed its appearance over the elementary form experimented with by Junger as to be quite unrecognizable. Thin sheet steel grids are used for holding both positive and negative active materials,—nickel hydrate and iron oxide, respectively. A solution of 21 per cent. potassium hydrate is used, having in addition a small amount of lithium hydrate. All metal parts within and without the cell are nickel plated. Even with this protection the oxidizing

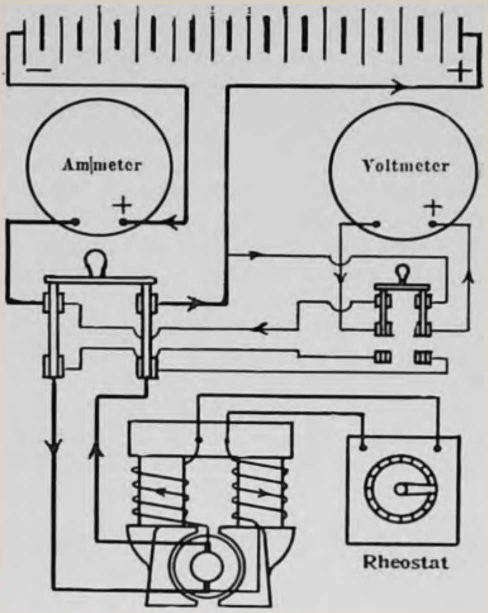


Fig. 13

action of the caustic potash is such as to require that the jars be wiped dry and then rubbed with vaseline.

The same troubles with expansion as are experienced with the lead elements have been met with in these, and the years of delay in placing the new battery on the market have largely been spent in devising means to prevent or care for this action. Then another difficulty was realized in the fact that the active materials are not naturally active in the desired degree and, further, were not good electrical conductors. The solution, too, does not have the conductivity of the sulphuric acid electrolyte of the lead cells. Yet in spite of these baffling experiences, and with an admitted gross efficiency of only 60 per cent. as compared with the 80 per cent. obtainable from new lead cells, remarkable performances have been accomplished with the alkaline type. Factors of first cost, weight, depreciation, renewals, and the like, suggest comparisons yet to be determined. In two particulars the new cell possesses unique advantages,—it can remain in the discharged condition without deterioration, and after periods of rest following rapid discharge rates, it will considerably recuperate its voltage. On the other hand, the higher efficiency of the lead type and the reputation for reliability it has earned for stationary purposes suggest its continued preference for such uses, and the Edison Storage Battery Company announce that they have no present intentions of competing for this class of service.

Whatever may be the make or size of the storage battery outfit, or its methods of regulation, certain fundamental principles underlie the successful or convenient switchboard operations. When a special generator is to be supplied, it should be of the plain shunt-wound type, a compound machine being too liable to reversals of polarity, while a series-wound machine is quite incapable of filling the needs. If a mercury-arc rectifier set is to be used, the special directions accompanying it make reference here unnecessary. For the ordinary case, a simple diagram of connections is given in Fig. 13. In this, a plain shunt dynamo has its armature terminals connected to the lower points of a double-pole switch, the battery to the upper. An ammeter is included in this circuit. Field current is arranged to pass through the regulating rheostat. The hinges of a small double-pole double-throw switch connect with a voltmeter. Both this and the ammeter should be of the permanent type sort, otherwise the important factor of proper polarity will not be safely determined. Small but well insulated wires connect the points as shown, so that before closing the main switch, the battery voltage may first be observed, then the generator adjusted to about the same value. Main switch can then be closed, and the voltage sufficiently raised to drive a suitable charging current through the battery.

An automatic over-load switch, usually called a circuit breaker, should be in the main line to protect the apparatus from excessive demands or accidental short circuits. Also, for shutting off the battery if the current reaches such a minimum as to result next in an unintended discharge, an under-load circuit breaker should be included. Of course ordinary fuses should also be provided.

Occasionally, or in the case of experimental apparatus, frequently, the polarity of the generator may be found reversed. To correct this it is not necessary to exchange the wires at the main switch, but to lift off one of the brushes, or in case the machine has more than two, all that are of the same polarity (putting pieces of cardboard under them will answer just as well), then close the main switch. Current will then flow through the field winding in the direction to give the correct polarity. Turn in all the field resistance, then open the main switch. The brushes may then be replaced, and the generator restarted. Such a procedure is an electrician's safe recourse in case he finds himself with a voltmeter of the electromagnetic type only. Evidence of a charging current is found in noting if gas is evolved from the cells. No such action accompanies a discharge.

Danger from High Pressure

It is related that when Massachusetts license law went into effect, there was among the applicants for a fireman's license, an old man who for years had been employed in one of the suburbs of Boston, cooking garbage which was used for feeding hogs. Replying to the varied questions of the examiner, he gave a description of the plant method of feeding by city water pressure, etc.

On being asked what steam pressure was carried, he said, with a rich brogue. "Tin pounds, Sorr." "Now," said the examiner, "you carry 10 lb. pressure to do your work. Suppose that while you were busy and not noticing what was going on, the steam pressure should run up to 50 lb., what would you do?"

With eyes of astonishment at the display on the part of the examiner of such abysmal depths of ignorance of the art of swill boiling, and trembling with indignation at the thought that such carelessness could be even mentioned in connection with him he hastily and hotly said:

"Oh, Sorr! The likes of ye shud know that it wud never do at all; it wud blow the schwill all to hell."—*Publicity Magazine.*

To find the resistance of a cable whose size is given in circular mils, drop one cipher from the number of circular mils, and the result will be the number of feet per ohm.

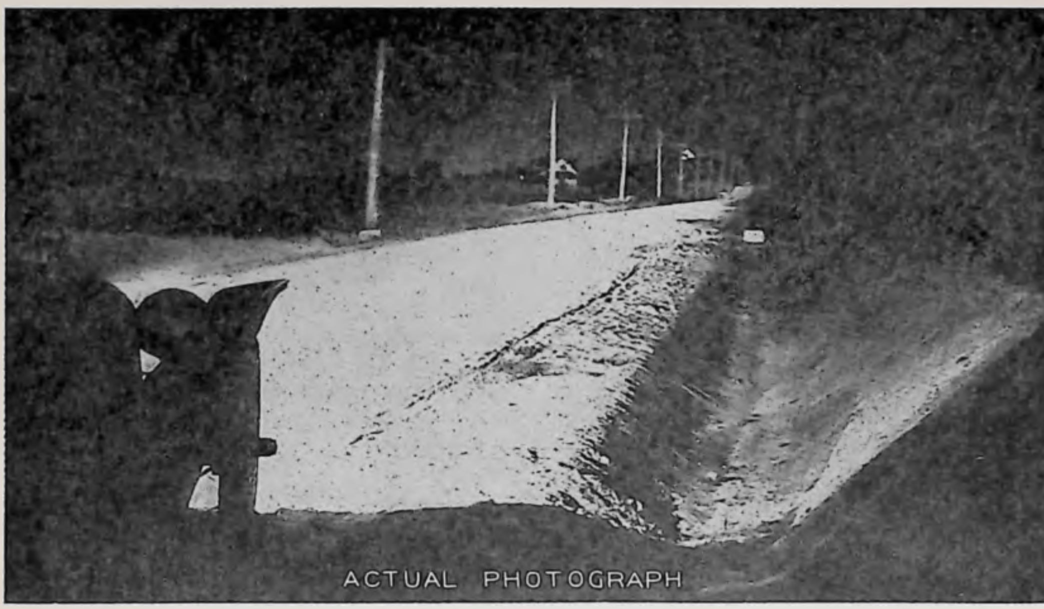
STORAGE BATTERIES FOR AUTOMOBILE ELECTRIC LIGHTING

GEORGE L. CHANDLER

Three years ago editors of several progressive automobile journals predicted the development and eventually the general use of electric lights on automobiles. At that time manufacturers admitted the need of improved lighting apparatus, but were skeptical as to the operating qualities of the electric lights then in operation; but, following out the rule that a strong demand will usually bring out satisfactory apparatus, practically 60 per cent of all 1912 models will be equipped with electric lights in side and tail lamps.

Of the various devices entering into the complete installation, the battery is the most important for the reason that it is the foundation of the entire system, acting as a reserve and regulator when used with charging dynamo, and as the only source of current supply when the dynamo is not used. There are, therefore, two distinct lighting systems.

In the dynamo lighting system, the dynamo and battery are used together, current for lights being taken direct from dynamo when car is running in some cases, in others the dynamo being used simply to charge the battery. The other system, known as the "straight storage" (battery) system consists of a high capacity battery used alone, it furnishing all the current required and having its charge renewed from some outside source, as at a garage or central station.



ACTUAL PHOTOGRAPH

Successful lighting of headlights was simply a further development, and we now have efficient and dependable systems giving instant service at the pressing of a button and an illumination as shown by the photograph reproduced above.

The advent of the improved Tungsten lamp made possible the first real progress and this has been followed up by improvements in storage battery, sockets, wire and other accessory fittings, the last step being the perfecting of small dynamos which automatically maintain the battery in a fully charged condition.

In the early stages attempts were made to operate lights from ordinary ignition batteries which was soon found to be impracticable, as this type of battery could not deliver the amount of current required, resulting in poor lights and injury to the battery. This condition resulted in the gradual development of a special type of battery of higher capacity, higher discharge rate and more substantial construction. The essential difference between an ordinary type of sparking battery and the improved type of lighting battery is in the batteries' normal discharge rate.

Another difference and one affecting the discharge rate is in the thickness of plates of which the battery is made up. In order to obtain higher capacity and higher discharge rate in a very compact space it is necessary to use plates somewhat thinner than those used in ordinary sparking batteries, this for the reason that a greater surface area of plate is presented for action of the electrolyte.

In the public mind there is much confusion as to what capacity a battery will give when discharged at varying rates; for instance, an ordinary 6-60 sparking battery discharged at the rate of 1 ampere per hour will give 1 ampere for 60 hours, but if current from this battery is taken at the rate of 6 amperes the battery will not stand this discharge rate for 10 hours as might be expected.

The table shown below will give a general idea of what might reasonably be expected of a battery of the lighting type when discharged at different rates:

LIGHTING BATTERY—Type ELB-60

Normal rating—6 volts, 60 ampere hours at lighting rate.

Discharged at 7½ ampere rate, battery will give 8 hours' service—total 60 ampere hours.

Discharged at 5 ampere rate, battery will give 14½ hours' service—total 72 ampere hours.

Discharged at 1 ampere rate, battery will give 92 hours' service—total 92 ampere hours.

The highest discharge rate above given (7½ amperes) is the average total current consumption or "lamp load" of an equipment for 5 lights.

From the above it will be seen that a catalog rating of battery capacity does not convey much information unless the rate of discharge is also given.

It has been thoroughly demonstrated that satisfactory results are obtained only when a battery is used which has a normal discharge rate properly proportioned to the maximum current taken by all the lamps. Users of batteries for electric lighting are learning that they must use a battery suited to the service requirements, and that they can no more get satisfactory results from too small a battery than they could from too small an engine.

The Elba line of lighting batteries manufactured by the Willard Storage Battery Company, represent the highest type of lighting batteries, for the reason that they have been developed and improvements in construction made as actual service conditions showed that changes were necessary. This battery is made up of three individual cells in which the elements are placed, these cells being made of a special composition of rubber which gives them strength without brittleness and at the same time makes them impervious to acid action.

These individual jars are placed in an outside wooden containing case, but have between each jar and also between the jar and the outside case a space which is filled with a semi-solid compound which acts as a cushion, thus enabling the battery to stand the rough usage of automobile service without injury.

Automobile service conditions also brought out the fact that there should be what is called ample "head room" in each cell. By this is meant the space above the plates and the first cover of the cell to allow for proper expansion during charging and also that there may be no doubt about the plates being fully covered by electrolyte.

This matter of expansion is further provided for in the Elba battery by placing between the first cover and the top cover a chamber into which the expanding electrolyte may flow when the battery is on charge, this chamber also receiving the electrolyte in case the battery is handled roughly. Batteries not having this chamber are subject to the "slopping" fault.

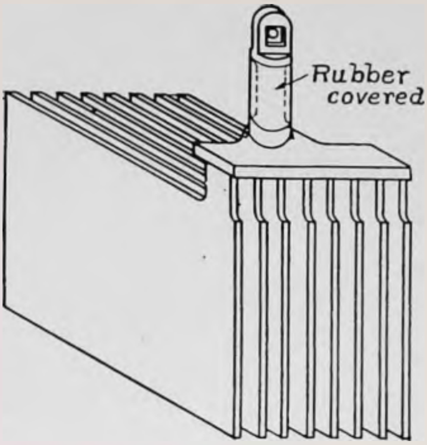
The distance between the first cover and top cover is ample and space around the expansion chamber is carefully filled with a sealing compound which is poured in hot, thus thoroughly closing every possible opening between the first and second covers and preventing acid creeping up the sides of the cells and around the terminals. The top cover through which the terminal binding posts protrude, is sealed in above the expansion space, completing the cell proper.

In the Elba batteries, the binding posts and straps to which the plates forming the negative and positive groups are attached, are a one-piece construction, and the plates themselves are lead-burned to the top connecting strap so that the entire group of individual plates, top connecting strap and terminal binding post are one integral unit, made generously substantial to stand the strenuous service.

Around the terminal binding post a band of hard rubber is vulcanized, thus preventing acid from creeping up the post and corroding at the point where outside wires are attached. With the Elba battery, lead-covered wires are furnished for attaching to the post, thus making a battery whose exterior is entirely acid-proof and by this construction the annoyance of corrosion is absolutely prevented.

It should be noted further that the construction as above described makes each cell an independent unit, and that there is no possibility of any connection between cells except such as are made from post to post above the top cover. This has the particular advantage of reducing the factor of local action between cells to practically nothing. This construction has also the advantage that any cell can be inspected or repaired without disturbing other cells. In the center of the top cover a hollow vent plug is placed, having in its center a small hole to allow gases to escape when the battery is charging or discharging. The outside containing case is made of hard wood, which is chemically treated to make it acid-proof, and it is then covered with an acid-proof paint.

From the above it will be noted that everything in this battery's construction has a definite *reason why* which has been found out and incorporated by experience in making batteries for automobile lighting. In the chemical formation of plates themselves the company draws on its nineteen years' experience and its practical knowledge gained in railway train lighting.



So much has recently been said in articles on automobile lighting about the need of a charging generator that some owners imagine they cannot get satisfactory service on straight storage; but, given a battery of the size suited to the maximum current to be used, very satisfactory results will be obtained on straight storage and at much lower expense for the original installation.

The smaller types of lighting batteries when used for operating side and tail lights have proved so very satisfactory that many manufacturers are now furnishing them as standard equipment and installing proper fixtures in side and tail lights.

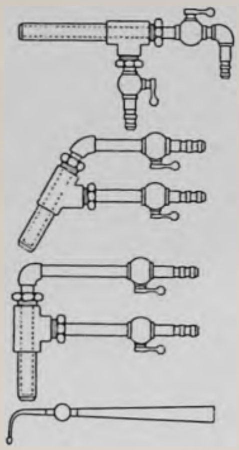
The dynamo lighting system has the

(*Concluded on page* 24)

SOLDERING AND BRAZING—Part II

H. W. H. STILLWELL

There are numerous conveniences that may be designed and made by the average mechanic which will be of great value in and about the workshop. The kinks and home-made tools described in this part of the article are simply suggestions, although all have been tried many times in practical ways and not found wanting. It is more than likely that ideas will suggest themselves to the workman that may be as good or suit the particular piece of work at hand better than those herein described, which indicates originality or inventive genius on the part of the workman.



BLOWPIPES

A good blowpipe is a very important factor in successful brazing, and, if one of the usual form is not at hand, there are many serviceable and efficient ones which can be constructed with the ordinary materials which are to be had about the shop, or can be purchased for a very little money from any hardware or plumbing establishment. Small brass gas fittings come in very handy for this class of work and can be obtained almost anywhere. It is necessary to use two sizes of pipe, so that one will go within the other and leave plenty of room for the gas to flow around it (see cuts). The nozzle may be any convenient length desired. Small valves or cocks should be placed in convenient locations on both the air and gas inlets, to regulate the flame. The small blowpipes, such as are operated by the mouth, are useful for very small articles which do not require the large flame of the gas-air blowpipe or the forge.

BRAZING KEYS AND RODS

Keys sometimes break at the stem by careless handling, and are usually discarded, the owner going to some expense and inconvenience to have another fitted. A key in this condition can be easily repaired and will give as good service as a new one. There are several methods of repairing broken keys and rods, but only the one which is most commonly used and considered the best will be here described. It is necessary in the first operation to file the ends of the article quite true; this will perhaps shorten the article ¼ in. or a little more; the joint will require about ¼ in. more. If this shortening of the article is undesirable, it will be best to use another bow or rod in place of the old one. A dovetail should be filed carefully, as shown in the illustration; a small half round or a small three square file will be very useful in making a good fit as this is very essential. When properly fitted, bind several turns of brass wire around the joint to act as spelter, apply the borax as a paste and then with tongs hold the key in the clear part of a small forge fire made with charcoal or small pieces of coke; or if a gas-air blowpipe is at hand, better results may be obtained, as the heat may be regulated and applied to the desired place much easier than with the forge fire. When using a forge fire on small articles, a guard plate is often used: a thick plate of iron with a hole of sufficient size to allow the part to be brazed to lie directly over it, the heat reaching the article through this opening. By this means the necessary local heating can be obtained, and much labor in cleaning the key or rod can be avoided. When the blowpipe is used much of this trouble can be dispensed with and better results are obtainable. Borax when heated swells up or boils and should be pressed down with a spatula, previously dipped in cold water to prevent the borax from adhering to it; a spatula can be easily made by flattening one end of a piece of round iron or steel wire about 1 ft. in length and ¼ in. in diameter or smaller;

an eye may be formed at the other end by which it may be hung when not in use. This spatula is also useful in adding powdered spelter or the borax to the work as required. As soon as the brass wire commences to run, assist the flow by adding a little borax; when the brass has run into the joint, rub off all molten metal underneath and allow the joint to cool gradually. When cold, file up, clean the stem of the key and polish with fine emery cloth or paper; or if a buff is at hand the operation may be accomplished with greater speed and results the better.

BRAZING WITH SILVER SOLDER

Many unexperienced persons fail, or do not get the best results from this method, because they do not apply the heat as continuously as they should. After the article has been thoroughly cleaned by filing, or scraping, add just enough solder and borax paste to make a good firm joint. Heat gently at first so as to harden the borax; then continue to heat by blowpipe until a red heat is reached, at which the solder will run. The secret is to blow steadily and not stop or decrease the heat until the solder will run freely.

BRAZING ARTICLES OF STEEL

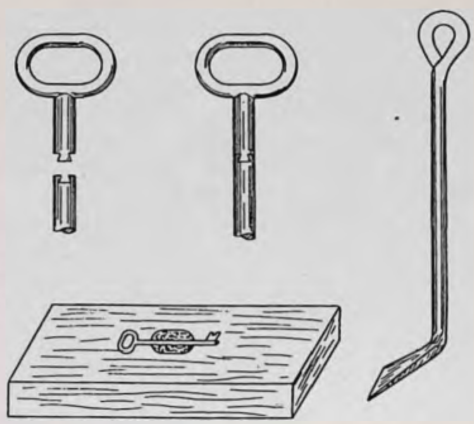
An excellent solder for this class of work can be made in the proportion of silver 18 parts, brass wire 2 parts, and copper 1 part. Melt in a crucible; when cold hammer into a thin sheet, or if a roll is convenient, it may be rolled to the desired thickness. It is sometimes preferable to granulate; this may be done by pouring the metal, while molten, into water. For small articles, a solder that will flow at a lower temperature than brass wire should be used. To braze or solder the article, clean the parts to be united very thoroughly and coat with pulverized borax, use a narrow strip of the solder and place on the parts to be united, then heat until the solder runs. This solder should be used sparingly to get the neatest and best results.

BORAX

It might be well to say a few words on borax at this place before proceeding further with this article. Water dissolves only a small quantity of borax properly. It is, therefore, not possible to mix borax powder and water in anything but a paste in which the borax sinks. This sinking of the borax will do no harm, as, when heated, it melts and spreads all over the work evenly. For small articles requiring a very little borax, such as spectacle frames, small keys, etc., lump borax rubbed down with water on a slate or like surface produces a paste much finer and of more even consistency than does the borax powder.

OTHER FLUXES

A flux, no matter what it may be, is simply a remover or preventive of the formation of an oxide during the operation of soldering and to allow the solder to flow readily and more evenly and to unite more firmly with the surfaces to be joined. The flux often differs with the class of work at hand. "Killed Acid," or as it is sometimes called, "Soldering Acid," or more properly



"Zinc Chloride," is very easily prepared as follows: Procure some pure zinc or as near pure as possible. Battery zinc is usually about as good as it is possible to get. Cut the zinc in small pieces and get a pint fruit jar with large opening. Into this jar pour about a half pint of C.P. or chemically pure muriatic acid, and drop the pieces of zinc into it. As soon as the acid touches the zinc, a bubbling or effervescence commences which will continue until the acid has taken up as much of the zinc as it can. The acid is now "killed" or saturated with the zinc. It is a good plan to let the solution stand over night and carefully strain off in the morning, throwing away the residue. If necessary it may be used immediately after the bubbling ceases, but it is much better to let it stand a while as before said. When prepared properly, this solution makes a very excellent flux for almost any class of soft soldering. This solution should be kept tightly covered by the screw top of the jar or a bottle with a ground glass stopper will serve the purpose very good. If the solution is allowed to evaporate and gets "strong" it becomes almost useless as it "gums" the work when heated; keep the air away from it as much as possible.

Rosin is often used as a flux and may often be used where an acid would be undesirable. Some engineers maintain that acid will corrode the work in electrical connections and others say that it will not. There are several compounds on the market which are prepared from resinous materials and are much used in electrical work and are recommended for this class of work in particular.

SIMPLE SOFT SOLDERING

For sheet tin on the best work rosin or colophony is often used. Zinc chloride is much used also, and owing to the rapidity of working it is quite popular. Beeswax can be used as almost any of the numerous pastes, fats, or liquids prepared for the purpose.

For lead, a flux of oil and rosin in equal parts will work very well. Tallow is also good. Rosin is much used and zinc chloride will keep the surfaces in good condition.

In soft soldering brass, almost any of the fluxes can be used. Care must be taken to remove all scale or oxide if a good joint is desired. It will be quite easy on new metal; but when repairs are to be made upon old metal such as castings, patterns, etc., it is sometimes very difficult. The scraper must be used to clean the surfaces, or if an acid dip is convenient, good results are often obtained by its use. If the work is oily or greasy it can be cleaned with potash or lye; care must be taken not to leave the article in this solution too long, especially if there are any other joints which have been previously soldered, the action set up will partly dissolve the solder or roughen up the joint.

For copper the same fluxes will do as for brass. If the work is old and dirty or tarnished, it is necessary to thoroughly scrape the parts to be joined, that they may hold firmly when completed. On old wash boilers, or bath tubs having a copper bottom or sides, much trouble will sometimes be experienced, as the grease and soap forms a coating that can not be acted upon by any of the ordinary fluxes and must be cleaned by scraping if the best results are desired.

In soldering zinc, greater care must be used than with some of the other metals, as it possesses what is known as a "critical temperature." If the soldering iron is heated too much, the zinc is melted and a hole will be burned into the metal. If this does not occur, the surface will be roughened up and an alloy is formed on the soldering copper which will not flow and is simply a pasty mass. When the proper heat is used, the solder will flow easily and the parts to be united will be joined firmly. If the article is to be painted after being soldered, care must be taken to wash off all the acid or soldering solution, as the paint will not adhere where there is a coating of either. As a flux for all zinc work, zinc chloride, or muriatic acid, almost full strength is used.

In galvanized iron work, such as cornices and ornamental work for buildings, etc., muriatic acid, zinc chloride, or rosin is used. Great care must be used in removing all the flux before painting, as many a good piece of work has been rendered very unsightly in a short time by the paint peeling off at the corners and wherever soldered parts were located. This could have been avoided if the operator had taken a little care to remove the flux before painting. Where galvanized iron is to be joined with copper, a very important item to be considered is the electrical action which is almost sure to be set up, especially in cities where acid in the air will assist in the action. The zinc or galvanized iron almost always is greatly injured by this action.

In soft soldering wrought iron or steel, zinc chloride is a good flux, but, as stated in another part of this article, if the article to be treated must stand strains or be subjected to rough handling, it may be best to braze with a good hard solder, using the borax flux as before stated. In soft soldering these metals, all scale or oxide must be carefully removed and then the surfaces tinned before joining.

(To be continued)

THE APPLICATION OF STORAGE BATTERIES TO STREET TRANSPORTATION

DAY BAKER

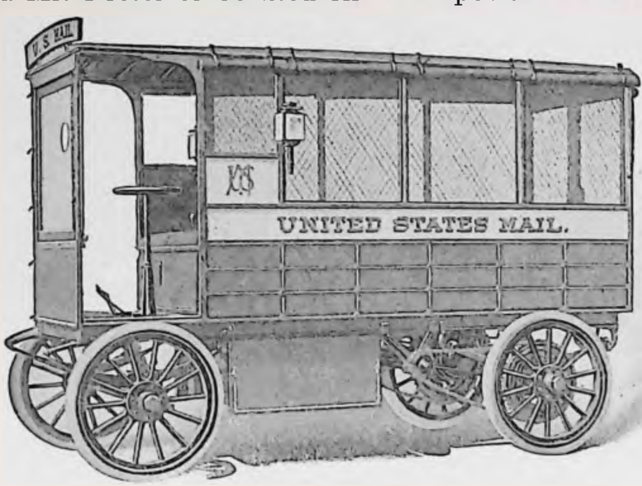
In 15 years, more Electricity will be sold for Electric Vehicles than for Light

Aug 8 1910 *Thos A Edison*

During the latter half of the nineteenth century, the inventive mind was at work on road vehicles to be propelled by some motive power other than the horse. A road omnibus or stage coach driven by steam power was early built and operated in England, but not proving a practical vehicle its life was brief. Shortly after Thomas A. Edison's invention of the generator and the incandescent lamp and Prof. Elihu Thomson's inventions, making the generator and motor practical commercial machines, the electric enthusiasts began to experiment and work on a road vehicle which should be driven by that subtle force, electricity.

In the spring of 1889, there appeared on the streets of Boston an odd-looking vehicle which caused many to stare in wonder. It was a tricycle, which moved over the roads almost noiselessly, propelled by a small two-pole 12 volt motor. The electric current was stored in six cells of accumulator battery. This machine was equipped with its electric drive by Mr. Fred M. Kimball, of Boston, for Mr. P. W. Pratt, of the same city, who used it for a short time, afterwards selling it to a Mr. Potter to be used on the Board Walk at Atlantic City. The speed of this machine was six miles an hour on level roads. So far as known to the writer, this machine was the first electrically driven automobile in this country.

In 1888 the Sultan of Turkey decided that he would like an improvement over horse-drawn vehicles, and he ordered of the house of Immisch, London, England, an electric dog cart. This was constructed of walnut and light woods finished in their natural colors. The upholstery was of brown cloth embroidered with the Turkish Imperial crest. The battery consisted of 24 cells of a special small accumulator type, which, according to the statement of one of London's engineering papers, would drive the cart five hours at a speed of 10 miles per hour, or 50 miles. The motor was rated as 48 volts, 20 amperes, 1,440 revolutions per minute, and ¾ h.p. The weight of the battery was 700 lbs. The armature shaft was extended to the full width of the vehicle and on each end were small sprockets, which, by means of roller chains and large gears on the rear wheels, conveyed the power.



One of Twenty-seven General Vehicle Mail Wagons Used in New York City

Trenton Tower Wagon in use by 3rd Avenue R.R. in New York City

So far as can be learned these two electric vehicles were the first to be constructed and actually operated. In 1895, Dedion of Paris, made quite a number of Victorias and dog carts, which were successful for that era. Twenty years ago Mr. C. W. Holtzer of the Holtzer-Cabot Electric Co., constructed an electric brake for Fiske Wallace, of Boston. It was not until 1900, however, that the first really successful electric vehicles were made, when the Baker Electric Vehicle Co., of Cleveland, Ohio, and the Pope Manufacturing Co., of Hartford, Conn., brought out electric storage battery vehicles for passengers which would operate with a fair degree of continuity. From that time to the present, the manufacturers of storage batteries and the builders of electric vehicles have constantly improved their product until today we have passenger electric vehicles that will travel all the way from 50 to 150 miles on one charge of the battery, and commercial electric wagons and trucks that will run from 35 to 60 miles on a single charge of the battery.

The first really successful installation of electric storage battery business wagons was made by Tiffany & Co., of New York, who started with three wagons of the General Vehicle type about ten years ago. To these three wagons nineteen more were soon added, and all of these are still in the service of the same firm, doing excellent work.

From 1902 to the present, the commercial type of electric storage battery vehicle has made steady progress. Many large mercantile houses, manufacturers and express companies have announced that they are to discontinue the use of horses, and are placing electric vehicles in service as fast as practical. In fact, there are already a large number of merchants who have adopted and are completely equipped with electric motor vehicles.

Electric storage batteries as used in both the pleasure or passenger vehicle and the commercial wagon and truck, are of two types: the lead plate and the nickel and iron plate. In the passenger vehicles no especial number of cells have been adopted as standard, although many makers use a 48 volt motor, which

Three and one-half Ton General Vehicle Truck used in San Francisco

Two-ton Electric Truck used by Pacific Mills, Lawrence, Mass.

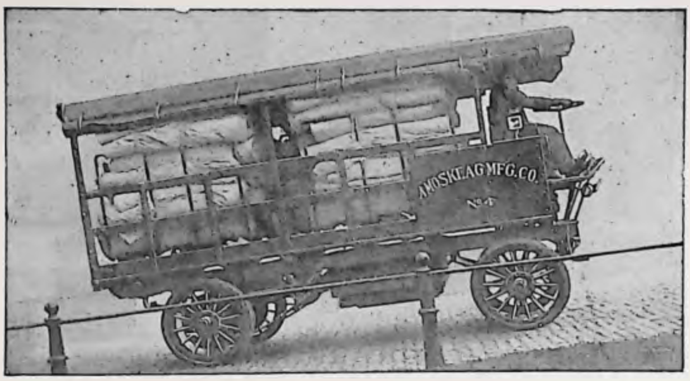
requires a battery of 24 cells of the lead type, which has a voltage of 2.04 per cell, or 48 cells of the nickel type, these cells having an average voltage of 1.2 each.

The batteries of the commercial vehicles have practically been standardized on 44 cells for the lead type, and 60 cells for the nickel type, as with these units batteries can be most economically charged from the commercial electric service of cities and towns, which is usually 110 to 116 volts of direct current.

Where direct current is not obtainable, a mercury arc rectifier or a motor generator set can be installed to change the current to direct, on which a battery must be charged.

The electric vehicle of the passenger or commercial type holds a field which is peculiarly its own. It should not be considered as a competitor of the gasoline-driven vehicle, which is especially adapted only for long runs without many stops. The electric is eminently fitted to be the successor of the horse-drawn vehicle, but possessing double the speed, and from two to three times the mileage capacity. In the case of the higher grade passenger vehicles the mileage is four to six times that of a horse used in a light driving rig.

For commercial deliveries and heavy trucking, the electric machine has admittedly the lowest cost of maintenance. The electric was first in the commercial field, the speed was moderate and the scope of operation limited to 35 to 40 miles. With the advent of the gasoline-driven business vehicle, with its bursts of speed, and its admittedly unlimited mileage, many users abandoned or stopped purchasing electrically-driven machines; but most of these enthusiasts after one to two years' experience with the gasoline machines, have, on account of their high maintenance costs, and finding that unlimited mileage was not



Two-ton Mill Truck used by Amoskeag Mfg. Co.

required, returned to the more moderate but reliable and economical electric vehicle; and it is to this class of purchasers, who are the large buyers of the country, that may be attributed the great increase in the electric wagon and truck industry for 1911. It is creditably reported that the orders placed during the first three months of this year, for electric vehicles, were greater than the whole business of last year.

In addition to the economy of maintenance of the electric vehicle, its simplicity of operation is such that any driver of horses, any lady or child can easily be taught in a few hours how to successfully operate it.

It is only during the past two or three years that the public have commenced to appreciate the true value of the electric vehicle in both of its fields. With this growing appreciation, its rapid adoption, and the formation of associations of manufacturers, electric light companies, and users, who are all working for its success, it may well be said that at last the true worth of the electric vehicle has been found, and it has been given its proper position in the motor vehicle world.

Application of Fan Motors for Winter Use

It is the popular opinion that the range of usefulness of the electric fan motor is limited to the summer months and that its sole utility lies in its application as a means of reducing the temperature of a room or an office, says *Practical Engineer*. This is not true, however, and slowly but surely the public is beginning to understand that the usefulness of the fan motor is by no means confined to the hot days of summer, and that paradoxical as it may seem, the electric fan blows hot and cold; and incidentally, while it is blowing hot it cuts the fuel bill.

Following are a few of the more important applications of the fan motor to winter use:

The efficiency of the hot air heating system may be greatly increased by placing a fan motor in the cold air box to force the air through the registers to all parts of the house. On particularly cold days when the wind is so strong that it forces the air through the furnace into the rooms without having become heated, a fan motor placed in the cold air box, after having closed the slide which permits air to come in from the outside and opening the slide which lets the air in from the cellar, will cause an appreciable rise in the temperature of the room, without making any increase in fuel consumption.

As is very often the case, the house contains a room or rooms which under certain conditions are difficult to heat. This difference can be overcome by placing a fan motor in front of the hot air register or over it in case the register is located in the floor. This plan will prove more efficient if the register and fan motor are covered by a box or hood of some kind which will cause the fan motor to draw air from the pipe only, and not from the room.

In a house heated by hot water or steam, increased radiation of heat and consequently a warmer room may be obtained by placing a fan at the end or back of the radiator.

Another manner in which the fan motor may be used to advantage in winter is to prevent the accumulation of frost on show windows of stores. The air from the fan motor directed against the glass of the window will keep it practically free from frost. This application of the motor is a boon to merchants who have, heretofore, during the cold weather lost practically all the advantage which their window display accomplishes.

Storage Batteries for Automobile Electric Lighting

(Concluded from page 17)

advantage that it is not necessary to remove the battery from the car for recharging, and with this type of machine in its present effective stage, the dynamo lighting system will surely come into general use especially on high-priced cars. However, as pointed out at the beginning of this article, it is the *battery* which operates the lights when car is standing or running at low speed, and thus it becomes the element on which dependability and certainty of operation depend.

SMALL ELECTRIC LIGHTING PLANTS

C. BELL WALKER

Summary.—The author, after discussing the main features of a small private plant for electric lighting, describes a plant which is entirely automatic in its working, being self-starting, self-stopping and self-regulating.

There has been a remarkable increase during the last few years, both in this country and abroad, in the number of small electric plants installed for lighting country houses, institutions, farms and numerous other buildings. This development has been due to various causes, including the public demand for luxury and improvements in the design and manufacture of engines, dynamos and storage batteries; but it is mainly traceable to the introduction of the metal filament lamp, which makes it possible to employ smaller cables and wires or, alternatively, a lower voltage and fewer cells in the battery. At present, for small installations, either 25 or 50 volt plants are almost invariably installed, and personally I am greatly in favor of the latter voltage, because of the better percentage regulation in potential when cells are cut in or out for this purpose.

It is not my object to compare electricity with petrol gas, acetylene, or any other form of artificial light, but it appears to me to be significant that the bulk of people who can have electric light, do so. Take up a Bradshaw Railway Guide and look through the hotel advertisements; wherever possible, they offer as an inducement to prospective visitors, "Lighted throughout by electricity."

At the present time there is not a very large opening for contractors among large houses—they have nearly all been equipped—but the man who has a house requiring 50 or 100 lights is following his more favored brother, and is having it lighted throughout by electricity. The next thing will be that the man requiring only 10 or a dozen lights in his house will not be satisfied until he also has electric light. At present, it is mainly a question of cost—not running cost, but capital cost—and, in the case of the small private installation, the amount of attention required. If, however, allowance were made for the smaller depreciation of furniture, etc., electric lighting would really be found to be the cheapest artificial light at present available.

Water power is occasionally procurable, and windmills are being used to some extent, but in both cases, the cost of adapting these forms of power is out of all proportion to the power obtained, and oil or petrol engines are usually employed to drive the dynamo in the case of small plants and suction gas or steam for larger ones. At present there is a great difference of opinion among engineers as to the relative merits of so-called high and low-speed engines. The low revolution engine is undoubtedly simpler and mechanically stronger, but, on the other hand, a larger engine room and more costly foundations are required. Starting is more difficult, and the overload capacity is usually less. The quick revolution engine is essentially a modern production, made possible by the growth of knowledge in the selection and production of high-class material and an extremely high standard of accuracy in manufacture. Ball bearings have not been used to a large extent up to the present, but there is a tendency in this direction. Dynamos are usually belt-driven when low-speed engines are used, and direct-coupled when driven by high-speed engines. There is also a diversity of opinion about the method of coupling, some makers preferring rigid and others flexible couplings. Personally, I prefer the latter, because it is possible for the wear on the engine bearing to be more or less than that on the dynamo bearing, in which case there is a danger of one of the shafts breaking. Again, vibration is transmitted directly to the armature through a rigid coupling, causing in some cases sparking, or, a more difficult trouble to prevent, crystalization of the armature connections where they join the commutator. As regards vibration, it is well to remember that it may only occur at a critical speed, in which case it can often be prevented by slightly raising or lowering the speed.

I should now like to describe briefly a house-lighting plant which is entirely automatic in its working: self-starting, self-stopping and self-regulating; and I will take as an example a plant suitable for a house requiring about 100 16 c.p. metal filament lamps, the voltage being 50. It comprises a two cylinder internal combustion engine capable of giving 3 b.h.p. continuously, using petrol as fuel, and running at a speed of about 900 revolutions per minute. The ignition is by high-tension magneto. This engine is direct-coupled by means of a flexible coupling to a differentially-wound dynamo, having its field windings so balanced that it gives a nearly constant output in watts at constant speed, irrespective of the variation in voltage due to the state of the battery or the number of cells in the charge circuit.

The automatic controller consists of an automatic battery charge and discharge regulator adjusted to operate at about 50 and 53.5 volts at the discharge terminals. In the charge circuit there is a time element reverse current circuit-breaker and a solenoid type automatic motor starter. Dynamo and discharge voltmeters are provided, the latter containing the switch which, through relays, controls the reversing pilot motor actuating the automatic battery regulator just mentioned. There is also a center zero ammeter to indicate the charge or discharge currents, or the difference between them. The automatic battery regulator is provided with pilot contact-makers to make and break the solenoid circuit of the starter and also a separate set to break the relay circuits when the regulator has reached the limit of its travel in either direction. A tumbler switch and a push switch are also fitted to enable the plant to be started or stopped at any time by hand irrespective of the condition of the battery. The method of working is as follows: To commence with, let us assume that the battery is fully charged, the engine having just stopped automatically, and that current is being used as required. It will be found that 23 cells will be sufficient for a short time to give between 50 and 53.5 volts. When they are not, owing to the drop in potential due to partial discharge, the automatic regulator immediately cuts another cell into circuit, making 24, and the voltage rises to about 52.4. In the course of time the voltage given by the 24 cells will drop to 50, and another cell will be cut in, and so on, until the whole battery of 27 cells is in use. Eventually, the whole battery will not maintain the pressure at 50 volts, the average potential across each cell then being 1.85 volts, but as the regulating cells have not been in circuit as long as the body of the battery, they will be reading higher than this figure, and some cells will, therefore, be only giving 1.8 volts, and are consequently discharged as much as is desirable. The battery regulator again operates to cut in still another cell, but instead of doing so, a contact maker on it energizes the solenoid circuit of the automatic starter and of the magnetic fuel tap, and so the dynamo is started as a motor, taking current from the battery, and the fuel supply is also turned on. The engine, being fitted with magneto ignition, and the speed being considerable, it fires almost immediately, and as soon as it has sufficiently accelerated, the motor becomes a dynamo and commences to charge the battery. We now get a rising voltage, and, as this reaches the maximum limit, 53.5 volts, cells are cut out of the discharge circuit by the automatic regulator, and when, eventually, 20 cells are sufficient or more than sufficient to give the maximum voltage, instead of cutting out another cell, the solenoid circuit of the starter and magnetic fuel tap is broken, thus cutting off the dynamo from the battery, and turning off the fuel supply. It will be noted that we have now completed the cycle of operations, the duration of which is dependent upon the amount of current used.

As regards the charging of the regulating cells, the contacts are so arranged on the controller that under normal conditions they receive slightly more charge than discharge and, after considerable experimenting, an arrangement has been ascertained which prevents these end cells from becoming overcharged to any extent. If desired, an attachment can be added, making the plant start up automatically on maximum demand. This consists of a current coil connected in the discharge circuit operating a solenoid core, which carries a switch contact. The plant can also be arranged to start automatically should it be used for supplying current to a motor working a pump, or for any other purpose, in which case a three-pole switch could be used in place of the ordinary double-pole pattern, the third pole being used as a pilot switch for starting the plant. A better method, however, is to have fitted a separate push-switch, because otherwise the plant would not stop so long as the motor switch was in the on position.

I have so far been dealing with plants suitable for places where only an engine is available for driving, but instead of an engine an electric motor can, of course, be used. There are two sets of conditions under which the system might be advantageously applied: for house-lighting off a direct-current traction circuit of 500 or 550 volts, or from an intermittent supply, such as a public generating station; or, on the other hand, it would enable the peak battery, which is usually at the central station, to be located on a large consumer's premises, thus saving considerably in the cost of mains. In conjunction with a time-switch, it could be easily arranged that current should not be taken by this motor-generator during the peak load in the case of a central station. It would also probably enable the supply authorities to take on a large consumer without adding to the existing mains.

In this country and abroad there are many central stations in small towns having only a very small day load. An opportunity might occur, however, for supplying a large house or hotel situated some distance from the station. The supply might be at 220 volts or even 440 volts three-wire. To supply this consumer under ordinary conditions a cable of considerable section would have to be laid and, in any case, the terminal voltage would be irregular owing to the greatly varying load affecting the drop in potential. By using a battery and an automatic generator the current could be used at the highest available potential, and the mains could be reduced to about one-fourth the size otherwise necessary. The voltage regulation would be greatly improved and, moreover, the current to charge the battery could be taken at any time during the 24 hours. It would, of course, be necessary to arrange that with a plant of this kind the controlling element should not be voltage drop on the battery, because the plant might then require to be started during the period when the whole of the lights were on and the motor-generator would be unable to supply all the lights and at the same time maintain the battery voltage. A time-switch, however, set to start up the plant each day, would ensure the battery being fully charged before the load came on.

This is not a new principle, but the automatic plant appears to make it practicable for a comparatively small consumer, where otherwise the cost of attention would be a large, if not the largest, proportion of the total cost. For engineers trying to improve the load factor of their stations it should pay them to supply current under these conditions at considerably less than the ordinary lighting rate.

It will have been noted that the system as I have described it is a voltage system. It is not, however, essential that the controlling feature should be the average voltage of the cells, although regulation must be effected in that way. The time for starting and stopping can be determined by a battery ampere-hour meter, or even by the gravity of the acid.—*The Electrician.*

Two Light-weight Alloys

Two remarkably light-weight alloys just introduced into industry are "metal cork" and electron. Both are considered superior to aluminum.

Analysis shows metallic cork to consist of 90.30 per cent. magnesium, with zinc, sodium, aluminum, and iron. The density of this alloy is 1.762, while that of magnesium is 1.74.

When this grayish white alloy comes in contact with water it frees a certain amount of hydrogen.

Electron has not as yet entered commerce. Its base is aluminum. This metal will be used in making the body of the new Zeppelin airship.—*Harper's Weekly.*

MAKING AN ACCUMULATOR

WM. C. HOUGHTON

The method of making accumulators here described has been used in the actual construction of many batteries which are in successful use.

There are in use at present two types of accumulator. One of these, the older form, uses plates or grids of lead with lead oxides either formed from the plates themselves or applied to suitable grids or frames, as the active material. Dilute sulphuric acid is used as the electrolyte or conducting solution in which the plates are immersed.

The other type, the much-advertised Edison accumulator, in which the grids are made of nickel-plated steel, and the active materials are oxides of iron and nickel. The electrolyte is caustic potash. The making of the latter type is out of the question for the amateur, as it requires a large plant equipped with special machinery and tools. It is also protected by patents, but the basic patents on the lead accumulator have long since expired.

An accumulator of this kind may be satisfactorily made with ordinary shop equipment, and even though it is somewhat limited.

The most difficult part of the work is the making of the grids. These must be so made as to hold the active material securely, and yet permit free access of the electrolyte and allow the chemical action on which the effectiveness of the accumulator depends. It should be kept in mind that there is no electricity in a charged accumulator. The charge is in the form of stored *chemical* energy, which is converted into electrical energy when the accumulator is discharged.

Grids are sometimes made of sheet lead, by drilling or punching holes for the active material, but this is a slow and laborious process. If many plates are to be made, it is better and cheaper to make a mould in which any number of grids may be cast. As iron is about the only suitable material for such a mould, the great difficulty is to provide it without the use of a full fledged machine shop. The method here described has been used in making moulds in which thousands of grids have been cast. No shop appliances except those ordinarily to be found in amateur's possession are required. A few ordinary woodworking tools—some drills, files, etc., will suffice.

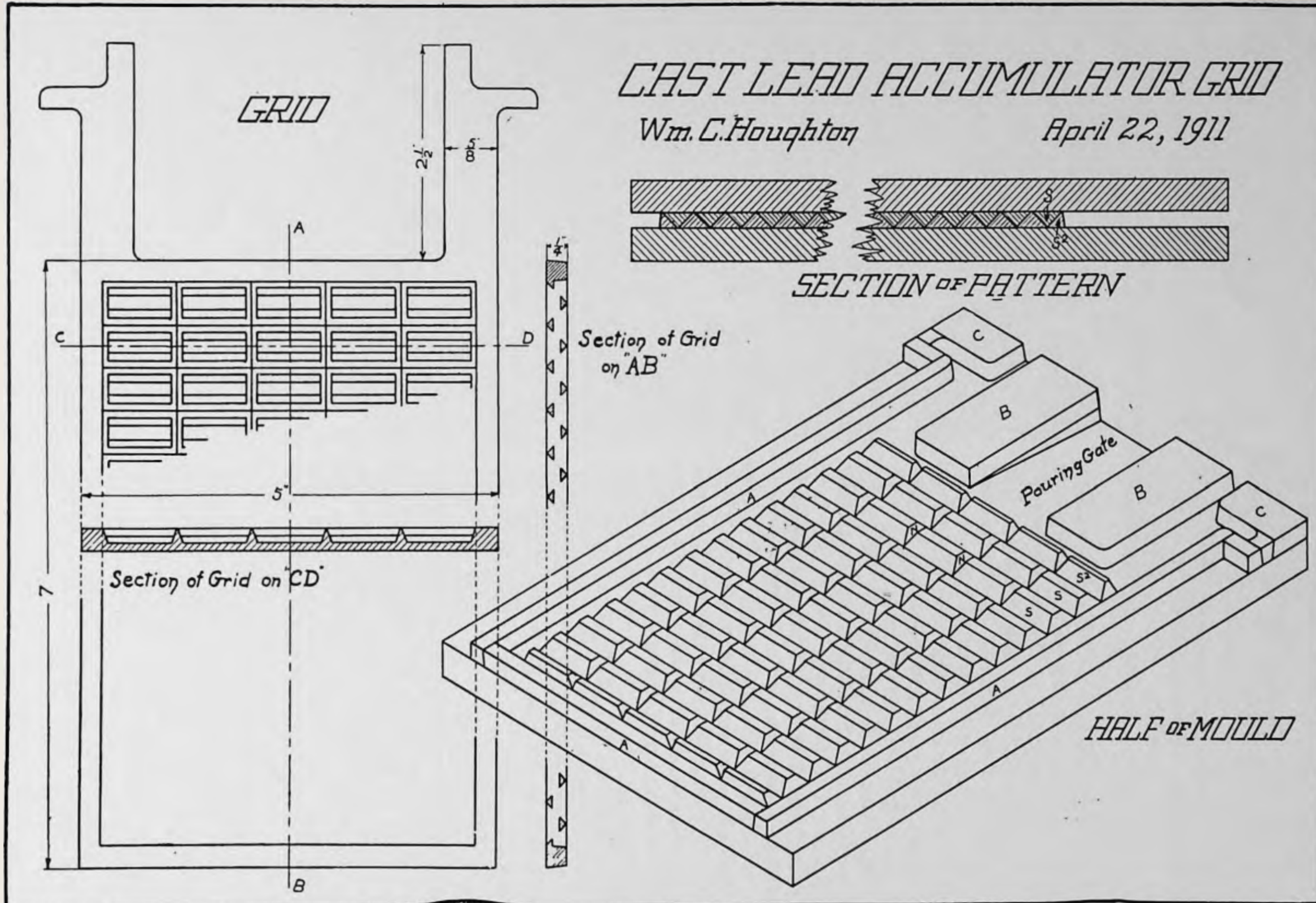
The first step is to get a wooden pattern for the foundation of each half of the mould. Take a piece of ½ in. clear pine board 6½ in. wide, and cut two pieces each 10 in. long. On one side of each of these make an outline of the frame of the grid only as per drawing on another page. The lugs and projecting pyramids for the grid proper need not be drawn; but care must be taken to leave room for the lugs, and to lay out the outlines to match on the two boards.

Prepare also a number of strips of pine ½ in. x ½ in., about 10 ft. in all. They must be planed straight and accurately to size. Saw each strip on the diagonal of the square, splitting into two triangular strips. Plane off the sawed faces until they come down to ½ in. wide. You will then have about 20 ft. of triangular strips ½ in. wide and ¼ in. thick.

Cut 18 pieces of this strip, each 4¾ in. long, and beginning ³⁄₁₆ in. from the inner line of the top of the frame drawn on one of the boards, glue them securely in place. The broad (½ in.) face of each strip should be toward the board, and they should lie closely edge to edge. Allow the glue to dry thoroughly, preferably under light pressure.

Cut 19 more strips to the same length, 4¾ in. Take two of these and plane off one edge of each to a much sharper slope than the 45 degree on the other edge. This will narrow the ½ in. face to about ⁶⁄₁₆ in. These are the strips marked *S*2 in the sectional drawing of the pattern. The other strips are marked *S*. The narrow ones are the first and last strips in the second half of the pattern.

Lay the second lot of strips ½ in. face up in the grooves between those already glued to the first half of the pattern.


CAST LEAD ACCUMULATOR GRID
Wm. C. Houghton
April 22, 1911
GRID
SECTION OF PATTERN
Section of Grid on "AB"
Section of Grid on "CD"
Pouring Gate
HALF OF MOULD
5"
7
2 1/2
5/8
1/4

Cover the part of the second board where the strips come with glue, press down on the strips laid in the other. Take care that the edges of the two boards come even. When dry remove the board and the strips will come with it. Notice that the two sets of grooves made by the strips will exactly fit if the work has been carefully done. The half patterns will be like the section shown in the drawing.

Next cut in each half the wedge-shaped depression marked *pouring-gate* in the drawing. The *fences*, however, marked *A*, *B*, *C* in the drawing, are not put on the pattern, but attached to the casting afterward.

The ends of the strips should now be trimmed off evenly, and slanted to give the pattern liberal draft.

The V-shaped notches *N*, *N*, may either be cut in the pattern or filed in the iron after the casting is made .

The second is the better way, but is perhaps a trifle harder: Give the whole pattern, front and back, two good coats of shellac. Be sure that they are smooth with no loose fibers to catch in the sand. Take them to the foundry and have one iron casting made from each. When the castings are done, snag them carefully; that is, file or grind off any fins or projections that may be left on them. Look particularly for any places where the bottoms of the V-grooves may be filled up more or less. Chip and file out any such places.

The next thing is to grind the two halves of the pattern to a fit. Scatter coarse emery over one of the plates. Wet the emery freely; put the other plate in place and scrub back and forth, grinding the top one down to fit the grooves in the lower one. Renew the supply of emery and water from time to time. When ground to a fit, all the grooves will look clean and bright.

Next, take a large, flat file and file off the tops of the strips on each piece, to a depth of 1/12 in.; that is, file off one-third of their height. This will leave the tops about 1/8 in. wide. If the notches *N N* were not cut in the pattern, they are to be laid out and filed now. In any case they must be touched up.

The border strips *A*, *B*, *C*, are now to be made and riveted in place on one-half of the mould. They must all be beveled on the inside about 1/32 in., in order to give free delivery of the casting.

The side and bottom strips are made of 1/4 in. cold rolled steel. What is known as key steel is smooth and straight and easily fitted. The other parts are also 1/4 in. thick, but shaped to suit. They must be sawed and filed to shape.

Put the mould together and see that the two parts fit snugly enough to hold the molten lead. When ready to begin to cast, prepare the mould by smoking the inside thickly over a kerosene lamp without chimney. This smoking must be repeated occasionally. Clamp the two halves of the mould securely together, and stand upright with pouring-gate up.

Melt the lead in an ordinary ladle. Have it hot enough to char paper, but not hot enough to burn it. Skim carefully and pour, preferably using a second ladle as a dipper, holding just enough metal for one grid. Success in pouring in an iron mould depends on getting the metal in quickly. For this reason the gate is made large, and the metal is to be literally *dumped* into the mould. The grid will harden almost instantly. Take off the clamps, knock out the casting, put together and pour again. The gate is to be cut off at the edge of the grid. A large and sharp carpenter's chisel is good for this. An old table knife and hammer will do nicely, however.

The negative plates should be of pure lead. The positives may have about 5 per cent. antimony added. It will make them stiffer, and they will resist the action of the charging current better.

(To be continued)

Experiments have been made by the United States Bureau of Mines at the Pittsburg experiment station to combine with coke as a fuel, limestone in such proportions as to flux the ash and form a liquid slag. This has been successfully done and the slag now runs freely from the producer, avoiding clinker and ash troubles with consequent shut-downs. Another advantage is the production of a high temperature in forming the slag which is very efficient in the generation of gas.

THE HOME CRAFTSMAN

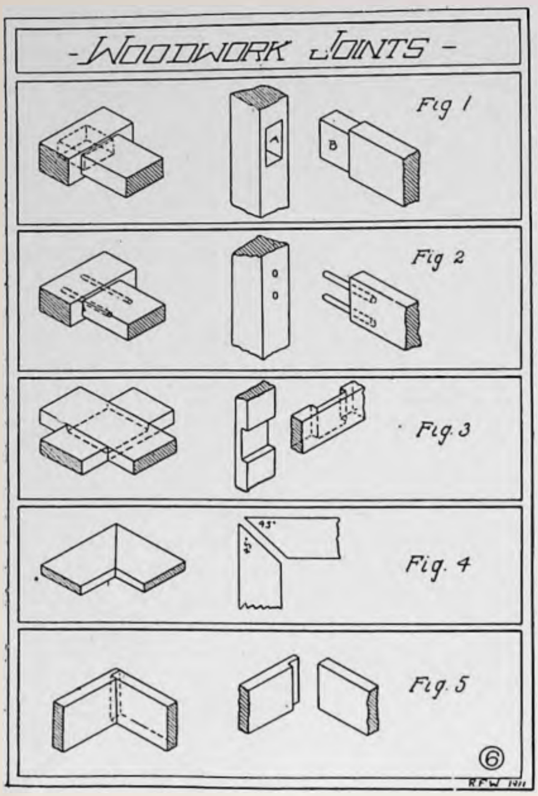
RALPH F. WINDOES

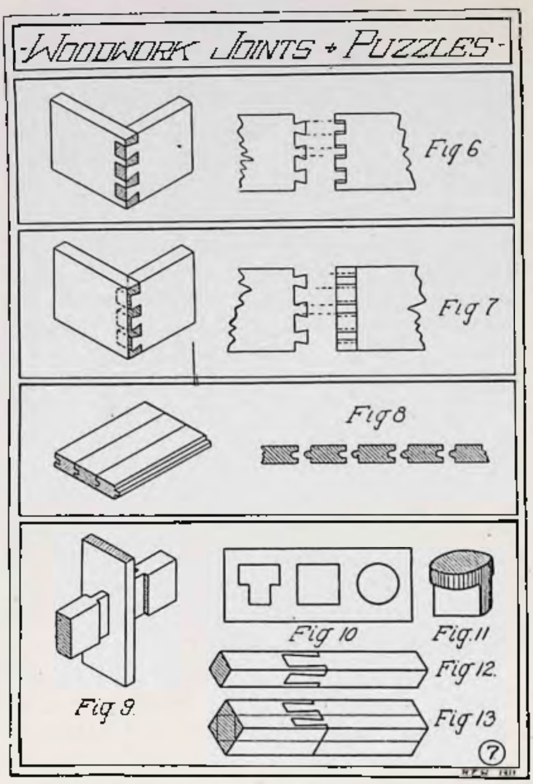
WOODWORK JOINTS

There are a number of joints used in woodwork, of which the craftsman should be thoroughly familiar. It is just as essential for him in his work to know the construction of these, as for him, in his living, to eat and sleep. It is advisable that he make a small model of each of the joints here shown, label them properly and keep them on hand for reference, as they shall often be spoken of in subsequent articles. Clear white pine would be the best wood to use, as it is easily worked up by the beginner.

Fig. 1 illustrates the joint most often used in cabinet work. It is the mortise and tenon joint. It is used largely where pieces are to be joined at right angles, and it has a large number of modifications. *A* is wood with the mortise and *B* wood with the tenon. Therefore, we often say that piece *B* is mortised into piece *A*, or piece *A* receives the tenon *B*. The joint here shown is the common, or half-blind, mortise and tenon, and is used where it does not matter if the tenon runs entirely through the other piece. In cabinet work we generally use the blind mortise and tenon joint, in which the tenon does not run entirely through the mortise. Neither does the mortise run entirely through the piece. It would be well to make a model of both of these.

Fig. 2 illustrates the dowel joint. It closely resembles the mortise and tenon and can often be used as its substitute, though it is advisable not to make a





practice of this. Dowel rod comes in a number of sizes and a number of woods. Maple rod about ¼ in. in diameter should always be kept on hand in the home workshop. To make this joint, bore holes in both pieces to be joined of the same diameter as the rod. We nearly always use two or more dowels in a joint to prevent the pieces from twisting, and the holes in each piece must be exactly opposite or the dowels will not go into place. When the holes are properly bored, drive the dowels in one of the pieces with the hammer, and place the other piece into position. It is a good plan to draw these together with clamps rather than by hammering, as this is liable to mar or crack one of the pieces. Glue may be used on the dowels and also on the pieces where they are joined, as this adds considerable to the strength of the joint.

A middle halved-lap joint is shown in Fig. 3. It is used quite extensively where pieces cross. It can also be used on corners, and is a very good joint to be familiar with. Its construction is very simple, and the craftsman should have little trouble in making his model.

The well-known miter joint is shown in Fig. 4. It is used almost entirely for picture frames and other corners, where it is desirable to hide the end grain. The two pieces to be mitered together are cut at an angle of 45 degrees, and when put together they should form a perfect right angle which may be tested with the try-square. The cutting may be done in a miter-box, or it may be done by marking out with the T-bevel set at a 45-degree angle. To get this angle draw a perfect square and a diagonal. The corner angles cut by the diagonal are 45 degree angles. Set the bevel accordingly. To fasten the miter joint it may be nailed and glued, held firmly, meanwhile, in the vise or with clamps. In gluing end grain, always size the grain first; that is, work glue into the end grain and let it dry before putting on the final coat which holds the pieces together.

Fig. 5 gives us the rabbeted corner. It is a joint very easy to construct, and is used a great deal in making drawers, in place of the dovetail joints shown in the next figures.

Fig. 6 is the common dovetail, in which the end grain of both pieces show. It would, therefore, be poor policy to use it for the front of a drawer of a piece of furniture, but it could be used to good advantage for the back piece. A study of the figure plainly shows its construction, also its great strength compared to the rabbeted corner.

In Fig. 7 we have the half-blind dovetail, in which the end grain shows on but one of the pieces. This, then, is the joint to use on the front piece of a drawer. It is the very best joint for such use, and has never had a satisfactory substitute. It is cut out entirely with the back saw and the chisels. Make a careful study of the figure before attempting to make it and little trouble should be experienced.

Fig. 8 shows the well-known tongue and groove used in gluing up table tops, etc. Few manufacturers take the trouble to use this joint in joining pieces, but there is no good reason why they should not on high-grade furniture. The home craftsman may purchase special planes for making the tongue and groove, or he may buy his lumber already formed that way.

The last five figures give us three puzzles in wood. They are easily constructed and much amusement may be derived from them.

Fig. 9 shows a hammer-headed key-piece running through another piece, both absolutely solid, and without joints. This is constructed in the following manner. Select some thin, hard wood and cut the mortise in the center of it, making the hole about the size of the center section of the key. Next, form the key which should be of soft white pine, and boil or steam one end of it until it is quite soft. Quickly put it in a vise and squeeze it until it is the same size as the hole. Take it out and waste no time in slipping it through the mortise, when it immediately begins to swell and with a little soaking will resume its former size and shape.

Fig. 10 illustrates a piece of wood with three holes of different shapes cut through it. It is required to make one plug to fit all the holes. First, cut the holes and do it very carefully. The diameter of the circle must be the same as the length of a side of the square, and the T-shaped hole is the same size as the square, both sections of the T being the same in width. Fig. 11 shows the plug that will fit each of the holes. It is formed from a cube, each of whose sides is exactly the size of the square. First it is made perfectly round, then the T is shaped as shown. When it is viewed from the top we see a circle, from the side a perfect square and from the end a T. If made correctly it may be thrust into each perforation and exactly fill each, thereby satisfying all the requirements of the case.

In Fig. 12 we have a mystifying dovetail splice, which, when constructed of two kinds of wood, presents a very puzzling appearance, especially if glued up so that it may not be taken apart. Fig. 13 shows how it is constructed. First, the double dovetail is made across one side of the piece, a very simple matter if care is used in so doing. Then it is glued and lines are gauged down the center of each side and connected on the ends, as shown. Lastly the corners are planed off to these lines and our puzzle is complete.

All of the model joints and the puzzles should be given two coats of shellac.

(To be continued)

THE MERCURY ARC RECTIFIER FOR ELECTRIC AUTOMOBILE CHARGING IN PRIVATE GARAGES

FRANK C. PERKINS

In a private garage the charging of storage batteries for electric automobiles is now easily accomplished, even though a direct current is not available from a central station circuit. A mercury arc rectifier equipment may be employed, as seen in the accompanying illustrations, Figs. 1 and 2, and drawings Fig. 3. This apparatus may be connected with any alternating current electric lighting or power service, and from it a low voltage direct current for charging an automobile storage battery may be obtained.

Besides the rectifying apparatus there is required with the mercury arc rectifier equipment an instrument for indicating the current flowing through the battery, and a volt meter for reading the voltage of the storage battery before and during the charging as well as adjusting devices for controlling the current used.

As noted in illustration Fig. 2, the mercury arc rectifier is installed at the top and at the back of the switchboard. It is held to be the most efficient device which can be utilized for charging electric vehicles' storage batteries from an alternating current.

In charging a 40-cell storage battery the efficiency is said to be at least 80 per cent., and the charging current can be started and adjusted in less than half a minute after the battery is connected. An equipment of 10 to 20 amperes may be employed to advantage in small private garages supplying from 5 to 45 volts direct current, when from 3 to 18 cells of batteries are connected in circuit for charging, the alternating current

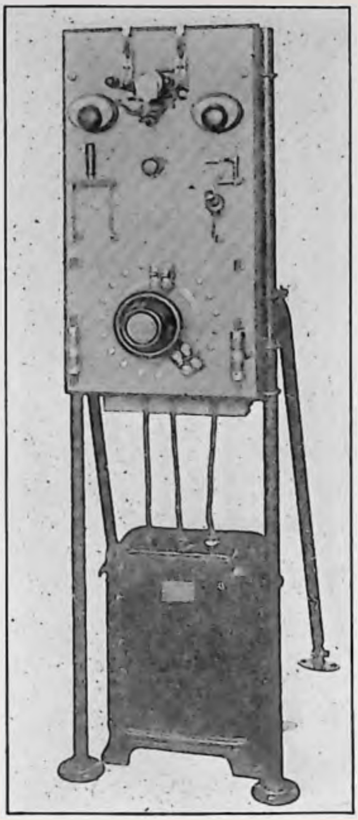


Fig. 1

having a frequency of 60 cycles per second and a pressure of 100 volts. A similar equipment can be utilized supplying a 10 or 20 ampere 30 to 75 volts direct current, or 20 to 120 volts for storage battery sets of 14 to 24 cells or 20 to 44 cells, the alternating current being provided at either 110 volts or 220 volts.

It is said that the mercury arc rectifier is less expensive than a motor generator set of the same capacity, while it requires but small floor space, and is remarkably high in efficiency at full and light loads as well as simple, flexible and reliable, while expert attention is not required.

Considering the theory of operation of this unique device, it may be stated that in an exhausted tube having one or more mercury electrodes, ionized vapor is supplied by the negative electrode or cathode when the latter is in a state of "excitation." This condition of excitation can be kept up only as long as there is current flowing towards the negative electrode. If the direction of the voltage is reversed, so that the

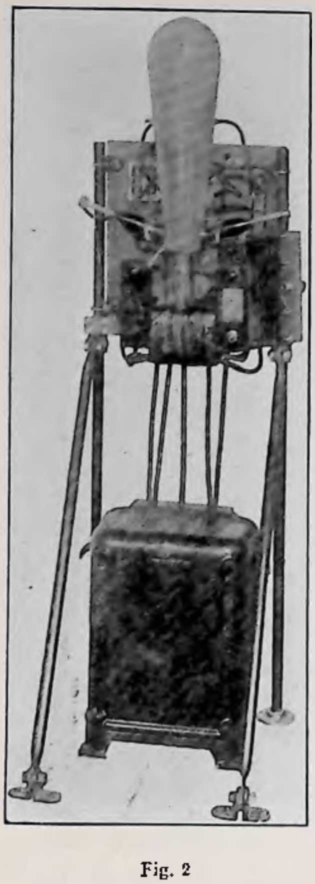


Fig. 2

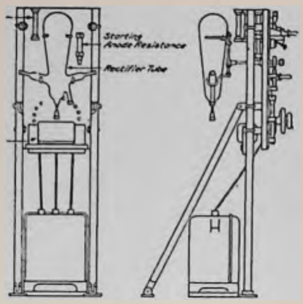


Fig. 3

formerly negative electrode is now positive, the current ceases to flow, since, in order to flow in opposite direction, it would require the formation of a new negative electrode which can be accomplished only by special means. Therefore, the current is always flowing towards one electrode, the cathode, which is kept excited by the current itself. Such a tube would cease to operate on alternating current voltage after half a cycle, if some means were not provided to maintain a flow of current continuously towards the negative electrode.

In the rectifier tube of the General Electric type there are two graphite electrodes and one mercury cathode. Each anode is connected to a separate side of the alternating current supply, and also through reactances to one side of the load. The cathode is connected to the other side of the load.

It will be seen that as the current alternates, first one anode and then the other becomes positive, and there is a continuous flow of current towards the cathode, thence through the lead back to the opposite side of the supply through a reactance. At each reversal the reactance discharges, thus maintaining the arc until the voltage reaches the value required to maintain the current against the counter e.m.f. of the load, and also reducing the fluctuations in the direct current. In this way, a true continuous current is produced with very small loss in transformation.

There is a small electrode connected to one side of the alternating current circuit, which is used for starting the arc. A slight tilting of the tube makes a mercury bridge draw an arc as soon as the tube returns to a vertical position, thus starting the action of the mercury rectifier, and the storage battery begins to receive a direct charging current.

NEW IRONCLAD-EXIDE BATTERY FOR ELECTRIC VEHICLES*

L. H. FLANDERS

The very simplicity of the electric vehicle at first tended to retard its development, no fundamentally new type of construction being deemed necessary. A battery and a motor on an ordinary vehicle made a horseless carriage.

An appreciation of what can be accomplished with properly-designed electrics has now been gained. This has been largely the result of a still growing spirit of co-operation between the vehicle-maker, the battery-maker, the central station, and the user, which has led each to study the general situation, and to try and adapt his special part to the best interest of the whole. The result is the rapid increase in the use of electric vehicles—both pleasure and commercial.

Home of the Ironclad-Exide Battery

BRIEF HISTORY OF LEAD STORAGE BATTERY

The battery generally manufactured for vehicle propulsion is of the lead sulphuric acid type. This type was discovered by a Frenchman, Gaston Planté, in 1860. It includes both the Planté and pasted types. To the Planté type belong all those lead batteries whose active material is obtained by means of chemical or electrochemical corrosion of the lead support plates, and whose electrolyte is a solution of sulphuric acid in water. Various modifications of the Planté type have been tried for vehicles with moderate success.

The pasted type, developed almost simultaneously in 1880 by Camille Faure in France, and Charles Brush in this country, is now generally used for electric vehicles. It includes all those batteries in which the active material consists of a paste made of lead oxide applied to a grid.

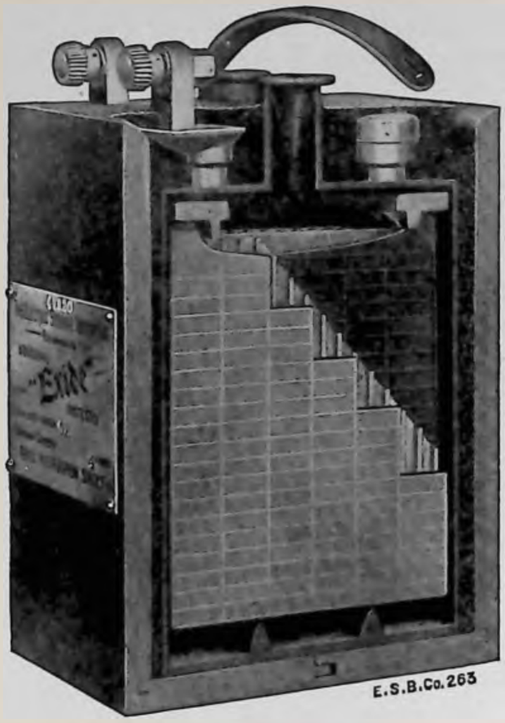
THE EXIDE BATTERY

In the development of the lead sulphuric acid battery for vehicle service, the problem has always been to secure high capacity per unit of weight consistent with durability. Although previously made spasmodically, the earliest application of the battery to the electric vehicle on a large scale was made in the late nineties, with the chloride accumulator, a modified form of the Planté type. Although at the time this was considered successful, and long experience has proved its durability, yet

*Abstract of paper presented at the Special Meeting of Electrical Section of the Franklin Institute, Tuesday, Jan. 3, 1911.

greater capacity per unit of weight soon became necessary.

To meet this need the "Exide" battery was introduced in 1900, and since that time has been a most widely-used battery for automobile propulsion. Although improved from time to time, it has remained unaltered in its essential principles. As this battery is so widely known, time will not be taken to further describe the details of its construction, except such features and characteristics as bear upon the further development of storage batteries for vehicle use.



Exide Sparking Battery

Among these is the form of grid made of a stiff lead alloy to give strength and resist corrosion. Its principal feature is the cage structure to hold the active material firmly in place in the form of a narrow vertical ribbon between vertical conducting ribs. This feature is used in all sizes and thicknesses of Exide plates, both positive and negative. The ribs and cross bars of the negative grid are lighter than those of the positive.

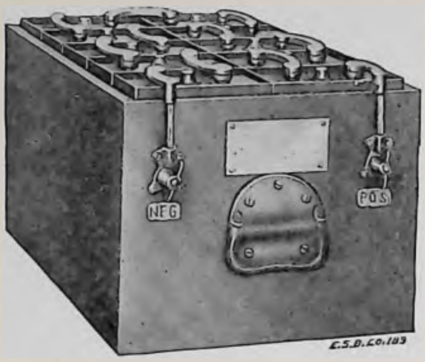
The positive and negative plates are made by pasting the grids with lead oxides and treating them electrochemically to produce a lead peroxide in the positive plate and spongy lead in the negative plate.

The Exide vehicle battery plates are manufactured in two standard sizes and several thicknesses, one of these being the Hycap Exide. The rating for plates known as Exide is based on a 4-hour rate of discharge, which is roughly one ampere per pound of complete cell. The capacity of the Exide plate rapidly rises in service, and then gradually falls off. However, the initial rating is conservative, so that if a battery be given its proper initial charge it will give the rated 4-hour discharge at the start. This will gradually increase in use to 4½ and even to 5 hours at the same rate of current. The increase to a maximum is more rapid than the dropping off from the maximum. This rapid rise in capacity at the beginning of service is due to the increasing porosity of the positive active material. This results in better diffusion of the electrolyte, which brings more of the lead peroxide into action on each cycle of charge and discharge. However, this rise in capacity is at the expense of active material. For, as more material is brought into action, the active mass softens, and then when the battery is charged some of the material is dislodged and settles to the bottom of the cell in the form of sediment. Incidentally, this explains why the life is shortened by too much charging. The capacity will increase as long as the rate of increase in the porosity is greater than the rate at which the active material is lost; but, finally, the loss of material will increase faster than the gain in porosity. When this condition is reached, the cell will begin to lose capacity.

POSSIBILITY OF FURTHER DEVELOPMENTS OF THE LEAD STORAGE BATTERY

From the foregoing discussion of the life of the Exide positive plate, it is evident that if the positive active material could be prevented from being detached from the supporting grid and still be retained in a healthy and operative condition, the plate would have a very much longer life.

The makers of the Exide battery have been improving the positive plate from time to time, and, while bending every effort to study and take advantage of the development of the art both in this country and abroad, they were attracted by the claims of a Frenchman who first demonstrated that if positive material could be kept in position it would remain active. He accomplished this by utilizing a pencil of lead peroxide surrounding a conducting core, and exclosed in a



Vehicle Battery in Case

porous tube of such elastic quality that as the active material expanded and contracted, due to changes in its molecular structure, the circular tube compensated for these variations. Thus the positive material was protected, and held in position. At the same time, this form, comprising, as it does, a central conducting core embedded in a cylindrical pencil of peroxide of lead, provides excellent conductivity and increased accessibility for the electrolyte, thereby rendering it possible to obtain a relatively high output from a relatively small quantity of active material.

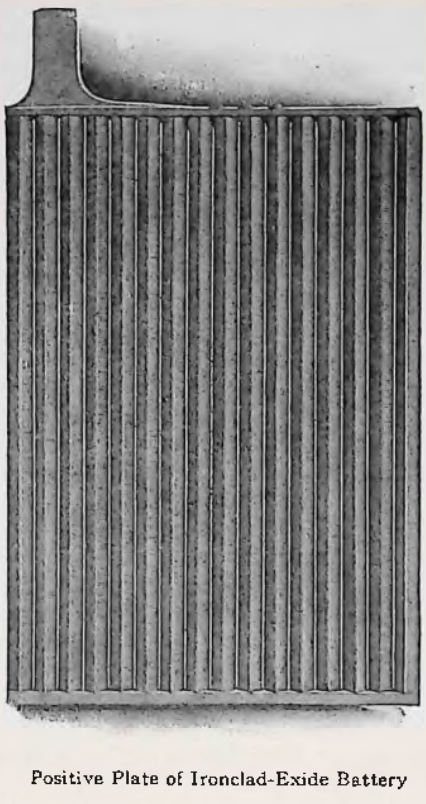
The makers of the Exide battery, after a careful investigation of this new battery, secured the American patent rights. For several years they have been actively but quietly carrying on a process of development in order to adapt the original form, which was somewhat crude and frail, to the demands of commercial use. As a result, they have developed a battery with a positive plate, which not only possesses all the desirable characteristics of the Exide positive, but which has even a greater capacity per unit weight, and which is so constructed that the loss of its active material is reduced to a minimum. On account of its remarkable durability, this battery is called the Ironclad-Exide.

THE IRONCLAD-EXIDE BATTERY

The positive plate of the new battery consists of an alloy framework, comprising top and bottom bars integrally connected by conducting cores of the same material. Surrounding these cores are the uniform pencils of active material protected by horizontally laminated rubber tubes. Each tube is formed with two narrow vertical ribs diametrically opposite each other, which take the place of the spacing ribs on the ordinary wood separator, and, at the same time, give added strength and durability to the tube.

The negative plate is of the same general construction as the regular Exide negative, but it has been made somewhat thicker in order to withstand the longer life of the Ironclad positive. The outside negative plates are thinner than the inside negatives. Both the positive and negatives of the Ironclad-Exide are made in the two standard sizes MV. and PV.

The plate-lugs have the same dimensions as those of the Exide plates of regular thickness, and the plate-center spacing is the same.



Positive Plate of Ironclad-Exide Battery

The wood separator used with this battery is a thin sheet of chemically-treated wood, flat on both sides.

The pillar-straps for connecting the plates are similar to the standard Exide pillar-straps. An improvement in detail is that the top of the pillar is bevelled, which facilitates burning the connecting-straps.

Pillar Strap Connector

A feature of the Ironclad-Exide battery is the flexible pillar-strap connector. It consists of alloy terminals cast around lead-plated copper strips, which give great conductivity and flexibility, and are replaced even more easily than the stiff pillar-strap connectors used with Exide batteries. These flexible connectors are standard with the Ironclad-Exide.

The jar is the same as that used for the Exide cell. The positive and negative plates are separated by the thin flat wood separators. No rubber separators are required, since the positive plate provides its own separator in one of its essential features—the rubber tubes with the ribs thereon. Otherwise, the method of assembling is exactly the same as that developed through long experience and employed for Exide batteries.

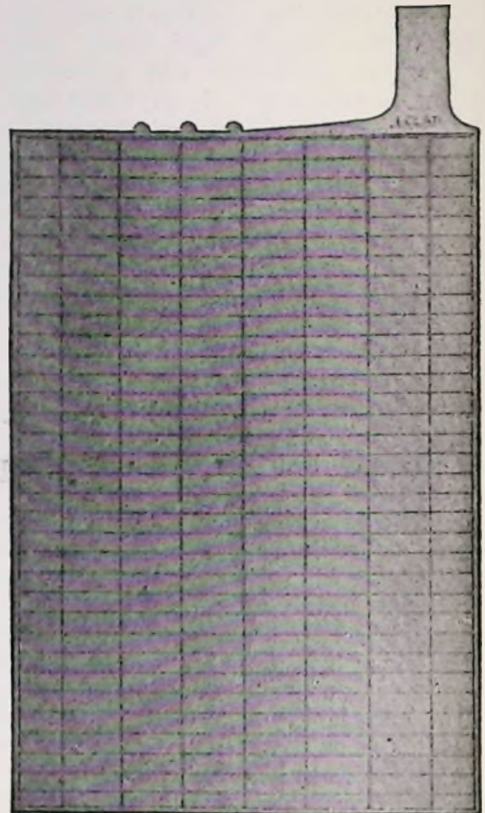
CHARACTERISTICS OF THE IRONCLAD-EXIDE

The Ironclad-Exide elements are interchangeable with Exide elements. Users of Exide batteries who desire to take advantage of the increased capacity and life of the Ironclad-Exide, can therefore substitute Ironclad-Exide elements for Exide elements without discarding any of the other parts of their batteries. Obviously, these elements may be put into any existing battery, having jars of appropriate size. To give a concrete example, a 24 cell 9 MV. Exide battery, weighing approximately 720 lbs. complete, including trays, and rated at 28 amperes for 4 hours, will receive 9 MV. Ironclad elements. It then will weigh approximately 740 lbs., with an initial rating of 28 amperes for 4½ hours, or 30⅓ amperes for 4 hours.

The rating is conservative, yet, when compared with the Exide positive, which is rated at 7 amperes for 4 hours, there is an increase of 12.5 per cent. in initial rating.

This battery, like the Exide, has the well-established advantages of the best lead storage batteries: high discharge voltage and high efficiency.

The same conservative rating is applied to the Ironclad-Exide as is applied to the Exide battery. Using the 4 hour rating of the MV. Exide, which has been taken as a standard in our previous discussions, at the same rate of discharge current per positive plate (that is, 7 amperes) the Ironclad-Exide battery weighing but little more, will start in at 4½ hours, which is an initial increase of 12.5 per cent. in ampere-hours output. It will reach a capacity of from 4¾ to 5 hours within about 25 discharges, and from 5½ to 6 hours within about 200 discharges. It will then retain a capacity above its rating for practically its entire life, in some cases reaching over



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Negative Plate of Ironclad-Exide Battery

1,000 cycles before dropping below its 4½ hour rating. The weight efficiency of the Ironclad-Exide will vary somewhat with the size of battery, mounting, and number of cells. A 24 cell 9 MV. Ironclad-Exide battery, arranged in three trays to the best advantage, would weigh approximately 740 lbs. The initial capacity at the 4½ hour rate would be about 8 watt hours per pound of complete battery, increasing to a probable capacity of over 11 watt hours per pound of complete battery.

The keynote to successful operation is system in the observance of the following salient points, which are here briefly touched upon:

1. Keep the electrolyte above the tops of the plates.

2. Add pure water in replacing evaporation, never acid.

3. When a battery is discharged, and especially when a vehicle is stalled, resulting in over-discharge, charge as soon as possible.

4. Do not overcharge unnecessarily, although by overcharging the Ironclad-Exide battery will not suffer damage to the same extent as other lead batteries.

Formerly, great stress has been laid upon frequent and systematic cleaning; but the Ironclad-Exide will rarely, if ever, require cleaning, since its actual material is so firmly held in place, and consequently the rate of sediment deposit is extremely slow. "To determine whether it will be necessary to remove the sediment, it is advisable, after the battery has been charged 250 times, to cut out for inspection one cell from the center of the battery. Then, from the height of the sediment, estimate its rate of deposit, allowing a sufficient margin in making the estimate to insure cleaning before the sediment can possibly reach the plates and shorten their life by short-circuiting them."

THE ALKALINE STORAGE BATTERY

WALTER E. HOLLAND

Nature provides us with three primary forms of energy: mechanical energy, chemical energy and heat. Electricity, the most useful form, is not native, but must be produced from one of the natural sources by a more or less indirect process of transmutation. Chemical energy, by far the most prolific source, is commonly transmuted first into heat, then into mechanical energy, and finally into electrical energy at an efficiency of less than 10 per cent.

In the ideal electric battery chemical energy is converted directly into electrical energy with 100 per cent. efficiency, and, except for a small internal loss due to resistance this will all appear in the external circuit.

All practical forms of electric battery combine conductors of the first and second classes, thus consisting of an electrolyte and two different metallic members called electrodes. There should be no action between the electrolyte and electrodes until current is drawn; then the current-carrying elements of the electrolyte should combine with elements of both electrodes to maintain the supply of current, such combinations being preferably of a nature that would reform electrolyte compensating for that decomposed.

Early in battery history it was discovered that acids made the best electrolytes, and Volta's original cell consisted of electrodes of zinc and copper in sulphuric acid electrolyte. Seventy years later, in 1860, Plante brought out the first useful storage battery, and this also employed sulphuric acid electrolyte, but had electrodes of lead and lead peroxide.

Now, it is a generality of chemistry, to which there are few exceptions, that a metal cannot long endure in contact with an acid, but the metal will displace hydrogen of the acid and combine to form a new compound. In view of this fact, it is strange that the alkalis, which rank close to the acids as electrolytes, and in whose presence many common metals can exist with perfect compatibility—it is strange, I say, that these were not used in any sort of battery until the year 1880, twenty years after Plante's achievement and ninety years after the inception of the electric battery principle.

During or soon after that year Lalande and Chaperon invented the zinc copper-oxide alkaline battery, which was later improved by Edison and which to this day remains the most efficient and durable battery of the class known as "primary."

As soon as this battery appeared, the value of a storage battery working on a similar principle was appreciated, and many attempts were made to commercialize it as such. The difficulties to be overcome were enormous, but inventors considered that to secure the advantages of an alkaline electrolyte any expense was warrantable, and the inherent defects negligible. The nearest approaches to success were made by Dezmazure, who, in 1887, operated a French submarine boat with his battery; and by Entz and Phillips, who operated street cars in New York with their Waddell-Entz battery in 1893.

The difficulties encountered due to the solubility of both electrodes proved too great, however, and the impracticability of using the zinc copper-oxide alkaline combination as a storage cell was practically proved.

At the outset of his battery campaign, Edison, recognizing the futility of pursuing further a principle which was necessarily faulty and against the laws of nature, put Satan behind him, that is, the acid battery, and turned toward the heaven of alkalis.

His first experiments had to do with the Lalande combination; but it did not take long to determine that electrodes of soluble materials could never serve the purpose. Then a radical departure was made when he discovered that finely divided cadmium could be used in place of zinc in the Lalande battery, and that this would oxidize and reduce in the alkaline electrolyte without going into solution. This led to the all-important discovery in 1901 of electrolytically-active insoluble iron which was not only cheaper than cadmium, but gave better voltage. The wonderful efficacy of peroxidized nickel hydrate as a depolarizer was discovered at about the same time, and as this too was absolutely insoluble in alkalis the combination was chemically perfect, and the principle of the ideal cell had become a fact.

The factors which determined Edison to go out for a storage battery, and the processes which led up to the final achievement, he has written in the following terse language:

"Started with the broad idea that displacing of horse-drawn vehicles in cities would be an immense advance.

"That the ideal vehicle was electric.

"That the electric never could be made commercial with the lead-sulphuric acid battery, which, while it was based on a unique reaction in chemistry and very beautiful in theory, did not and never could fit in to meet the commercial requirements.

"I believed that nature could afford one more reaction, and I started, avoiding every combination requiring acid.

"After an enormous number of experiments I at last found a reaction that although very weak was promising, and I pursued this for three years, finally producing the first type of the nickel-iron alkaline battery."

It is interesting to note that from the very first he has concentrated his attention on a battery for use in the field of vehicle propulsion. His first alkaline battery patent makes mention of the qualities most needed in vehicle service. It says:

"The object of this invention is to provide and produce a reversible battery which is light, portable and durable."

Since vehicle propulsion is the most difficult field of service, obviously a battery meeting its needs would fulfill the requirements of almost any other condition.

The first discovery of the elements of the Edison battery was rather easy as compared to the development and practical application of the principle. Three different commercial types of cell were brought out—type C in 1902 and types D and E in 1903—all of which were unsatisfactory for one reason or another; and real success was not attained until the year 1908—seven years after the announcement of Edison's discovery—at which time the radically different construction embodied in the present A type cell was perfected.

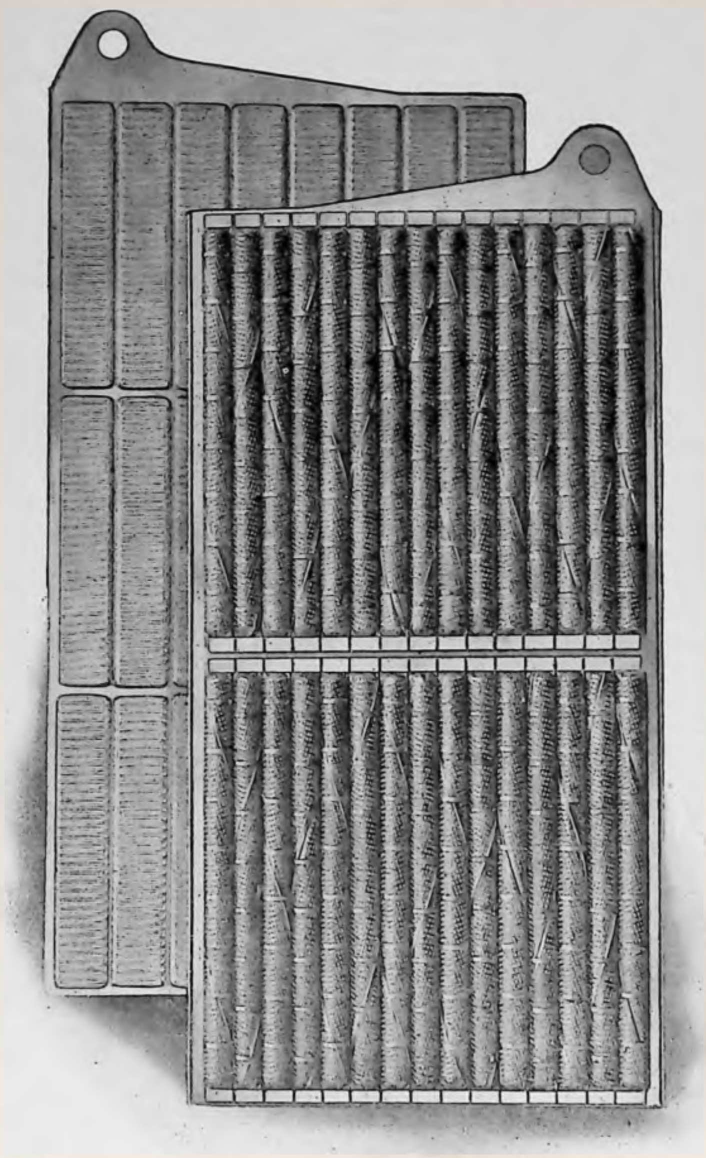
Before looking into the construction, the working principle of this battery must be considered. The active materials in a charged Edison cell are metallic iron in the negative electrode and peroxide of nickel, probably hydrated, in the positive. The electrolyte is a 21 per cent. solution of potassium hydrate, containing lithium hydrate in small quantity.

The positive or nickel-plate consists of one or more perforated steel tubes, heavily nickel-plated, filled with alternate layers of nickel hydroxide and pure metallic nickel in exceedingly thin flakes.

The tube is drawn from a perforated ribbon of steel, nickel-plated, and has a spiral lapped seam. This tube after, being filled with active material, is reinforced with eight steel bands, equidistant apart, which prevent the tube expanding away from and breaking contact with its contents.

The tubes are flanged at both ends and held in perfect contact with a steel supporting frame or grid made of cold rolled steel, nickel-plated.

The negative or iron plate consists of a grid of cold rolled steel, nickel-plated, holding a number of rectangular pockets filled with powdered iron oxide. These pockets are made up of very finely perforated steel, nickel-plated. After the



Positive and Negative Plates

pockets are filled they are inserted in the grid and subjected to great pressure between dies which corrugate the pockets and force them into practically integral contact with the grid.

After the plates are assembled into a complete element, narrow strips of treated hard rubber are inserted between the plates, thereby separating and insulating them from each other. The side insulator is provided with grooves that take the edges of the plates, thereby performing the dual function of separating the plates and insulating the complete element from the steel container. At the ends of element, that is, between the outside negative plates and the container, are inserted smooth sheets of hard rubber. At the bottom, the element rests upon a hard rubber rack or bridge, insulating the plates from the container at the bottom. This bridge is shallow, providing very little sediment space or "mud cellar"; such provision, fortunately, is unnecessary in the Edison cell, for no active material is precipitated.

The jar or container is made from cold rolled sheet steel of fine quality. The container is welded at the seams by the autogenous method, making leakage or breakage from severe vibration impossible. The walls of the container are corrugated so as to give the greatest amount of strength with minimum weight. The steel is heavily nickeled as a protection from rust.

The cover is of the same quality sheet steel and is nickel-plated. The cover is provided with four mountings, two being pockets for containing stuffing boxes about the terminal posts. One of the other two is the separator, so called because it separates spray from the escaping gas while the battery is charging. The fourth mounting is an opening for filling the cell with electrolyte, and for the adding of distilled water to take the place of that which evaporates during charge. This opening is provided with a water-tight and air-tight cap, held in place by a strong latch. Attached to the cap is a small helical spring which holds the cap open until properly fastened with the latch. This reduces the possibility of leaving the cap open accidentally, thereby causing the electrolyte to spill out should the cell for any reason be violently agitated.

The active materials are not put into the plates in the charged form, but the iron as a mixture of oxides and the nickel as the green nickel hydrate. The first charge reduces the oxides of iron and oxidizes the nickel hydrate, and, thereafter, they probably never return to their initial condition. In each subsequent cycle the negative charges to metallic iron, and discharges to iron hydrate, while the positive charges to a peroxidized hydrate of nickel, and discharges to a lower hydrate.

Current passing in either direction, charge or discharge, decomposes the potassium hydrate of the electrolyte, and the oxidations and reductions at the electrodes are brought about by the chemical action of its elements. An amount of potassium hydrate equal to that decomposed is always reformed at one of the electrodes by a secondary reaction, and consequently there is none of it lost, and its density remains constant.

The ultimate result of charging is a transference of oxygen from the iron to the nickel electrode and of discharging a transference back again, and this is why the adjective "oxygen lift" is sometimes applied to the Edison cell.

Innumerable repetitions of tests have shown that cells as commercially manufactured by the Edison Storage Battery Company have surprisingly uniform capacity, and that under any similar conditions, no matter how abnormal, different cells will give practically identical results.

The output of the cell is determined by the capacity of the positive or nickel electrode. It has been found best in every way to design the cell with sufficient allowance of iron active material to give considerable excess capacity to the negative.

Test electrodes of either cupric oxide or electrolytic nickel-oxide may be used successfully for analyzing the voltage curves of the Edison battery, and the writer, applying the principle of these further, has found electrolytic peroxide of lead far superior to the universally used cadmium as a test electrode material for use in the lead-acid battery.

Cells do not have as high capacity

when new as after some weeks of use. The betterment comes from an improvement of conditions in the nickel electrode, which is brought about by regular charging and discharging. Overcharging expedites this self-formation and is recommended. Every cell manufactured gets three overcharge runs before leaving the factory, which is always sufficient to bring the output up to the rating, but full capacity is not attained until after at least twenty complete charges and discharges.

The output and efficiency of a cell, working at ordinary temperatures, depend upon three factors, the rate of charge, the amount of charge and the rate of discharge. Best results are obtained charging at normal to two-thirds normal rate, but much higher rates may be employed with little sacrifice of efficiency.

The Edison cell has an air-tight cover, a valve being provided for the escape of gas. Practically no water is lost by evaporation, therefore, and a battery can be left idle for months without attention, and there will be no danger of the solution becoming low. Water is lost when a battery is working, however, and this results entirely from overcharging; for any current which is not used to effect the chemical changes at the electrodes goes to produce hydrogen and oxygen, the elements of water, which are emitted as gas.

To replace this loss, pure water must from time to time be added. The figure of ampere-hour efficiency represents the proportion of a charge which goes to produce the desired chemical changes at the electrodes, and the difference between this figure and 100 represents the loss of water.

Constant current discharges of the Edison battery, at no matter what rate, are found to give a quite constant output figure if carried to very low voltage, and differ only as to average voltage.

Cells have been subjected to various severe and even abusive tests at the Edison laboratory, the results of which are very interesting; but these cannot be taken up in detail here, so the demonstrated advantages and characteristics peculiar to the Edison cell will merely be mentioned.

The damage done to lead cells by sulphation through standing wholly or partly discharged is well known, and when such battery must remain out of commission for some time it is necessary either to give it freshening charges at frequent intervals or else to give it a complicated shelving treatment, involving much labor and trouble. The Edison battery can be set aside and forgotten in any state of charge or discharge for a practically unlimited length of time without fear of injury.

Top View of Cell with Cover removed

The materials used in the cell being exceedingly durable by nature and the construction being very rugged, a cell will stand an almost unlimited amount of vibration and shock without injury. For shock tests a jolting machine is used which lifts a cell ½ in. and drops it on solid wood about 60 times a minute. In one case a 18½ lb. cell was dropped 1,750,000 times in this machine with practically no effect on its electrical characteristics.

The perforated container construction prevents loss of material by disintegration, doing away with sediment short circuits and the necessity of cell washing.

The many troubles heretofore caused by corrosive fumes, jar breakage and plate buckling are all eliminated with the Edison battery, and furthermore no harm is done by charging in the reverse direction or even by completely short circuiting a fully charged cell. In fact, this remarkable cell thrives on short circuit discharges. Normal tests made before and after nine short circuit discharges showed an actual improvement as a result of the drastic treatment.

Light weight in a battery gives it many evident advantages and makes possible the building of vehicles of exceedingly high mileage capacity. No other commercial battery in the world can honestly claim to compete with the Edison battery in this respect; its normal output per pound of complete battery is 14 to 18 watt hours, depending upon the type of cell and the length of charge.

The crowning feature of the Edison battery, however, is its marvellous durability. This renders it a dependable piece of apparatus instead of a makeshift which has to be humored, coaxed and doctored. This point has been demonstrated in many laboratory life tests, but the most convincing proof comes from actual service, where thousands of batteries are now giving excellent satisfaction. The oldest batteries went into commission two years ago and are doing the same work now as then, showing practically no deterioration.

As an English authority once said, in speaking of the Edison battery: "It is one of the striking features of the cell that it recommends itself by work more than can be done by any verbal account."

Novel Fuel Supply

This sounds like a made-up item concocted by some reporter in an off hour when his imagination ran away with his sense, but it is really no worse than other things which have appeared in newspapers from time to time. The source in this case is the *Herald*, of Syracuse, N.Y., and the item is given by *The Locomotive* in a recent issue.

"For the last month the sawmill here has been running on a fuel which puzzled the fireman of the boiler, and not until Friday did he solve the enigma.

"Several weeks ago the fireman was feeding the firebox a cord of 4 ft. wood a day; while today he uses only a few sticks in the morning to start the fire. The boiler is fed from a creek back of the mill, a 3 in. pipe running from the boiler to the stream. This creek is noted for its small eels. The eels ran up the pipe to the injector on the boiler and were forced into the flues (!). The hot water soon cooked the eels, and investigation showed that the boiler contains several barrels of eel oil. The flues of the boiler leak,—not badly, but just enough to let the oil into the firebox, where it keeps up a seething flame."

As a method for getting fish chowder and operating a boiler at the same time, this has certain advantages; also it contains a suggestion for those who believe in the use of kerosene as a boiler compound. Let it work as a compound first, and then leak through into the firebox and serve to keep the boiler running.

Earned a Portion

Sammy had accompanied his father to a lecture. The boy had been promised five cents, provided he sat quietly during the evening.

After the lad had stared at the ceiling for what seemed a long, weary while to him, he whispered to his father:

"Isn't it more than half over, father?"

"Yes, yes, my boy; but keep quiet."

"Well, father," persisted Sammy, "if it's more than half over, you can give me three cents and we'll go home."

We are not suffering so much from the high cost of living as we are from the high cost of waste.

WIRELESS TELEGRAPHY

In this department will be published original, practical articles pertaining to Wireless Telegraphy and Wireless Telephony

CONSTRUCTION OF RECEIVING APPARATUS FOR A MODERN WIRELESS STATION

W. C. GETZ

In presenting this final article of the series dealing with the construction of a modern wireless station and the necessary instruments, it has not been found possible to introduce any especially new features of importance, but merely to treat of the best practice in modern instrument design, and to furnish suitable data that will enable the experimenter to construct the instruments described.

As stated in previous issues of this magazine, a general form of all receiving circuits is a fixed or variable capacity connected to a fixed or variable inductance, containing in the circuit a wave-detecting device which will actuate a suitable indicator, such as a pair of telephone receivers, and while there are various methods in which the capacities and inductances may be combined, they nevertheless follow the general form stated above. In this respect the experimenter should be warned against the danger of having too many pieces of apparatus connected in. Certain wireless "experts" have evolved many beautiful diagrams fairly bristling with inductances, variable and fixed capacities, promiscuously distributed over the landscape, and for which it is claimed will eradicate all the existing evils of static, interference, etc. While these may accomplish what is claimed for them, they frequently give the operator so many things to adjust and fool with, that by the time he tunes the sending station in, it has half finished the mes-

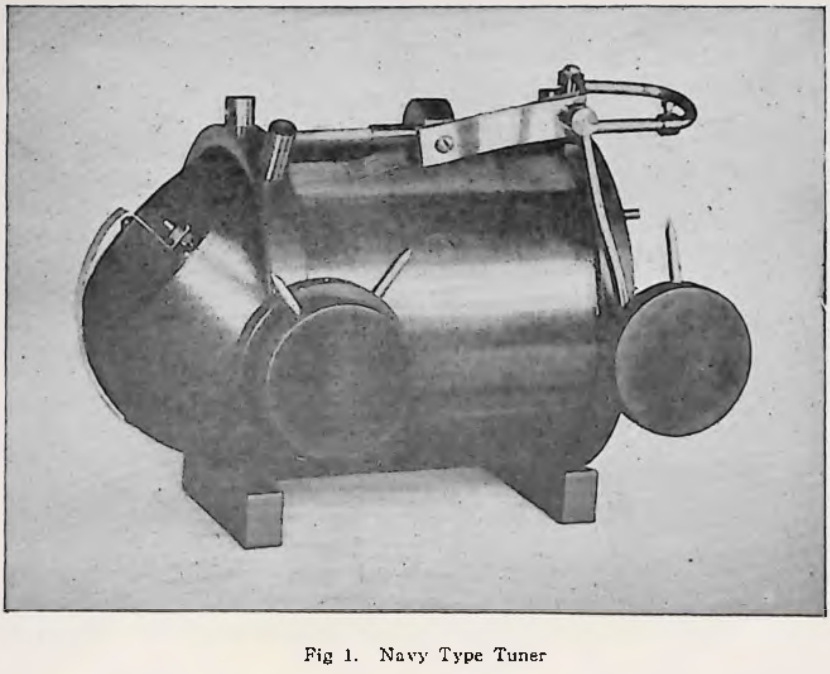


Fig 1. Navy Type Tuner

sage. Wherever possible, make your circuits simple, as you will be able to work much better than where you have to be continually adjusting a number of devices, each of which requires several seconds attention.

THE INDUCTIVE TUNER

The inductive tuner or oscillation transformer has been adopted as the most efficient and satisfactory type for the present installation. There are a number of prominent and well-made types of inductive tuners sold by the various dealers in wireless supplies. In Fig. 1 is shown the recent "Navy Type" of inductive tuner brought out by the Clapp-Eastham Co. The variation of coupling in this tuner is accomplished by rotating the plane of the secondary coil from a position parallel to a position at right angles to the primary winding. This is an exceedingly well-constructed device, and gives excellent results.

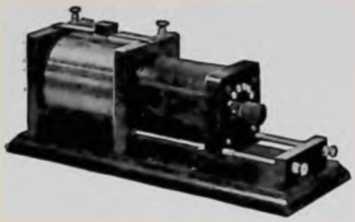


Fig. 2. Receiving Transformer

The Wm. J. Murdock Co., have also brought out a very good tuner. This is shown in Fig. 2, and the writer has been in a number of experimental stations where this instrument was giving extremely fine results.

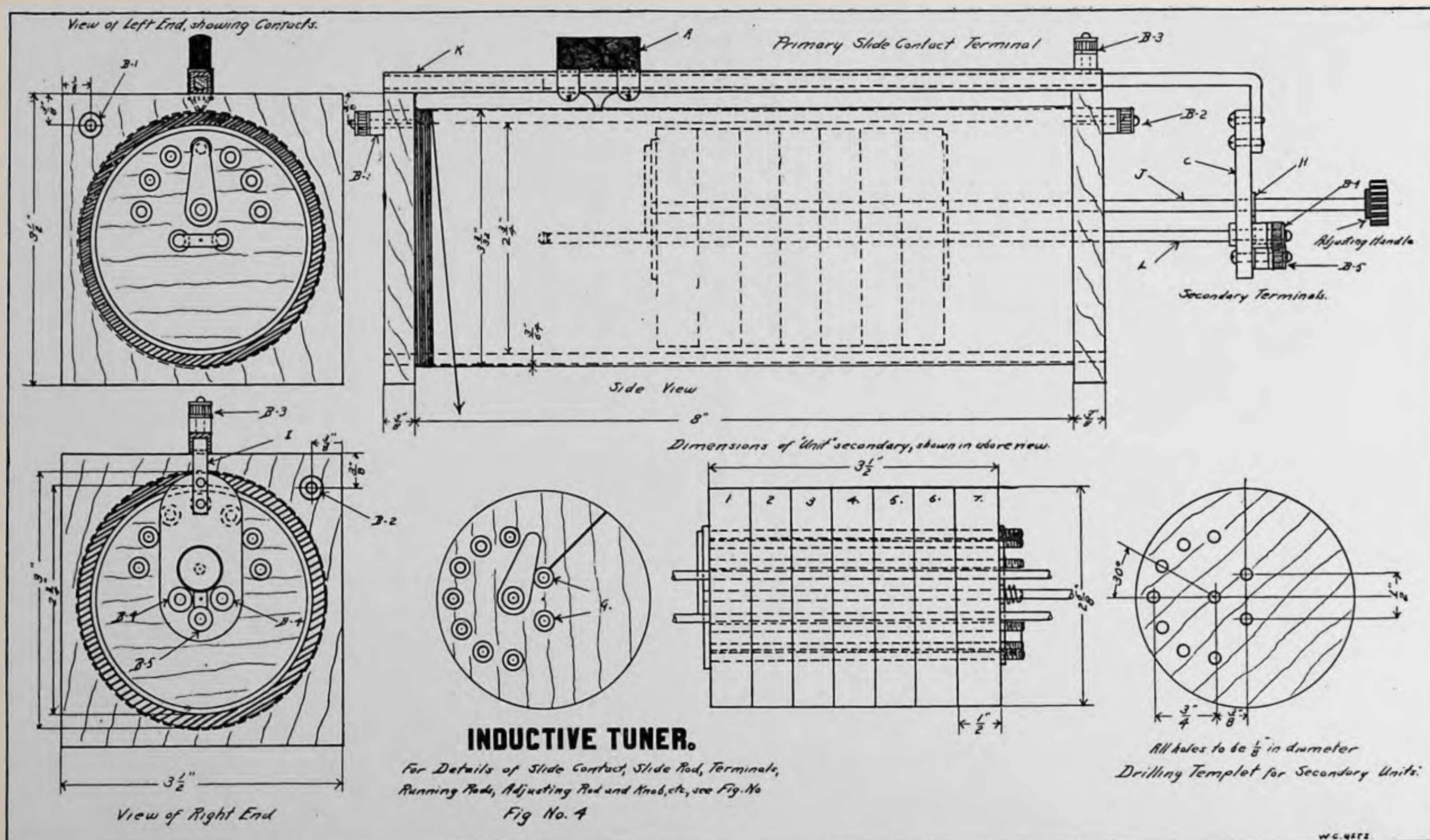
In Fig. 3 is given a view of an inductive tuner of familiar appearance, that was constructed by Lieut. J. O. Mauborgne, in the Signal Corps Laboratory, at Fort Leavenworth, Kansas. As this instrument was easily constructed, and very successful in operation, a brief description will be given of same: The primary consisted of 100 turns of No. 18 enameled wire wound on a cardboard mailing tube 4⅜ in. outside diameter, and with a ⅛ in. wall. One sliding contact is provided for the primary winding. The secondary consists of 300 turns of No. 24 single silk-covered magnet wire wound on another cardboard tube 4 in. outside diameter, and with a .2 in. wall. The secondary was brought out in taps as follows: 1st, at beginning of winding; 2d, at 40 turns; and 3d, at 300 turns, the end. The detector is mounted on the base of the coil and the condenser (fixed) concealed beneath the base in a pocket.

Fig. 3

In all of the above-mentioned types of tuners, the amount of wire on the secondary winding is a fixed quantity. Now, referring to Fig. 4, I have given a drawing of an inductive tuner, the secondary of which is built on the "unit" plan, in sections. The top views in this drawing show the left end and the side elevation of the tuner. The lower views show the right end, the assembly of the secondary, with the appearance of the faces of the secondary sections.

As seen from the sketch, this tuner is similar in many respects to that shown in Figs. 2 and 3. The primary consists of No. 16 B. & S. gauge enameled wire, and is wound on a tube 2¾ in. inside diameter, and 3 in. outside diameter. This gives a ⅛ in. thickness of wall. The tube may be of either cardboard or fiber. The primary tube is 8¾ in. long, and on each end is fitted an oak end piece 3½ in. square and bored out to fit the tube. This will leave a winding space of 8 in., which will accommodate about 145 turns of the No. 16 enameled wire. Approximately 1 lb. of this wire will be needed for this winding.

The sliding contact rod *K* is mounted on top of the coil in the center of the ends as shown. This rod, as given in detail in Fig. 5, is of square brass tubing, 5/32 in. square inside, and ¼ in. square on the outside. One end of this is drilled with a No. 29 drill and tapped for an 8-32 machine screw stud, which supports the binding post shown in the side elevation.



INDUCTIVE TUNER.

For Details of Slide Contact, Slide Rod, Terminals, Running Rods, Adjusting Rod and Knob, etc., see Fig. No.

Fig No. 4

The sliding contact A, details of which are given in Fig. 5, consists of a brass slide cut and bent as shown, with a hard rubber handle on top. Through each of the "legs" of the slide, brass studs are passed which hold the contact maker. This consists of two pieces of No. 18 spring brass wire, each bent as shown in the sketch, and soldered together at the bottom. If correctly made as shown in the drawing, this slide will be found superior to any other type, as it is easy to manipulate, exerts a steady pressure, does not cut the winding, and makes a positive contact with one convolution at a time.

To support the secondary winding properly, the extension rod I is used. This rod is of 5/32 in. solid brass bar, and is bent down at one end for a distance of 5/16 in. The straight length of the bar is 8¾ in. The bent end is drilled and tapped for two 8-32 machine screws, as shown in the sketch. This rod slides into the sliding contact rod K, thus allowing the secondary to be withdrawn for a considerable distance from the primary where very loose coupling is desired, and at the same time it can be telescoped for convenience in portability.

To I is fastened the insulating plate shown at C on Fig. 5. This is made of ¼ in. hard rubber and is drilled with a number of ⅛ in. holes in the positions shown. It is 2 in. long and 1 in. wide, with rounded ends. In the two lower off center holes the ends of the running rod L are placed.

As in the detail drawing, the rod L is bent so that the ends are parallel to each other, ½ in. apart, between centers. The ends are threaded with 8-32 threads, for ½ in. from end. In fastening this to plate C a nut is placed on each end of the rod and screwed down as far as it will go. Then the plate C is put in position, and the binding posts screw on the projecting ends of the rod, holding same rigid. The rod is of ⅛ in. round brass.

Before placing the rod in position we must assemble the secondary. As stated, the secondary consists of a number of sections. In Fig. 4 is shown the plan of a unit of seven sections. Each section consists of 30 turns of No. 26 B. & S. gauge enameled magnet wire, wound on a wooden disk 2⅝ in. diameter and ½ in. thick. For the seven sections about ¼ lb. of No. 26 wire is needed.

The wood should be made of the same material as the ends of the sections, and should be smoothly and accurately finished. In each disk are bored a number of ⅛ in. holes, as shown on the drilling templet in the right-hand corner of Fig. 4. The two holes on the center line are for the running rod L. The seven holes on the ¾ in. radius are for the connecting studs, and the center hole of these is for the adjusting rod and switch arm.

Seven studs, size 8-32, as shown at F in Fig. 5, should be obtained. On the end of each stud is placed a threaded washer, as shown at G, and when the end of the stud is screwed flush with the face of the washer, they should be soldered together. With a file remove any excess solder, so that there will be a smooth surface for the switch arm to make contact with. The studs are then slipped in the respective holes of the first section, the washers being on the left side.

Now the left end of the winding on the first section will be carried to the bushing G, shown on the front view of the secondary unit in Fig. 4. This makes contact with the running rod L. It is merely one of the small washers bored sufficiently large to allow the ⅛ in. rod L to slide easily through it.

Referring to the diagram in Fig. 6, the following may be better understood. The right end of the winding of section 1 is on the side next to section 2. This and the left end of the winding on section 2 are carried down and connected to stud 1, between sections 1 and 2. In a like manner, the end of 2 and the beginning of 3 are connected to stud 2 between 2 and 3; 3 and 4 to stud 3; 4 and 5 to stud 4; 5 and 6 to stud 5; 6 and 7 to stud 6; and the end of 7 to stud 7.

If it is desired, only one or two of these sections may be placed on, as at a later time additional sections can be easily added. And another thing, units with different sizes of wire may be substituted without unwinding any sections or unsoldering any connections.

After all the sections that it is desired

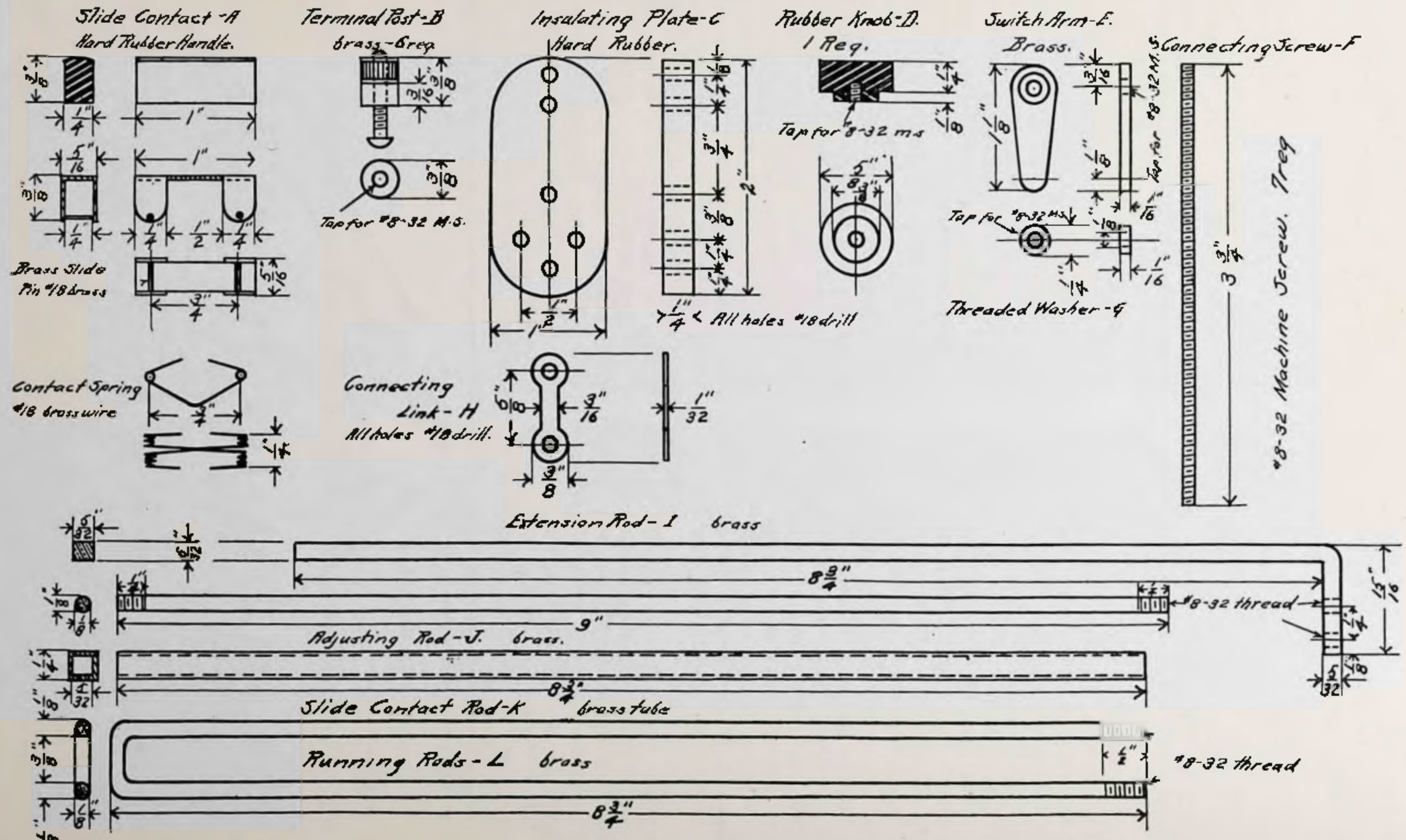
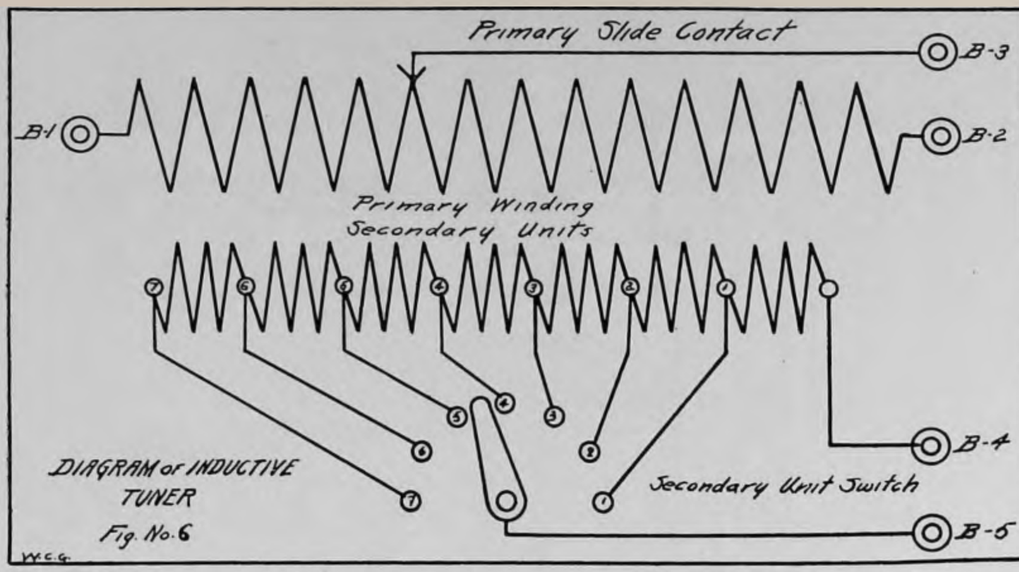


Fig. 5. Inductive Tuner Details



to use are in position, threaded washers are placed on the other ends of the studs and tightened up until the entire unit is perfectly solid and even.

In the center hole is placed the adjusting rod *J*. On one end of this rod is the switch arm *E*, shown in Fig. 5, and on the other end, the insulated handle *D*. The rod is of 1/8 in. brass, and is 9 in. in length. The switch arm is of 1/16 in. brass, and is 1 1/8 in. long. The knob is of hard rubber, 5/8 in. in diameter. Both the knob and the switch arm are threaded to fit the thread on the rod. The switch arm should be soldered to the end of the rod. To protect the switch arm from getting shoved away from the contact ends of the studs, it is necessary to place a washer reamed out to fit over the rod *J* on it, opposite the switch end. Against this washer should be placed a small compression spring. The spring may be made as follows: Drill a 1/32 in. hole in the rod *J* about 1/4 in. to the right of the washer, which is up against the right side of section 7. In the hole slip the end of a length of spring brass wire, and slowly wind the wire on the rod, until within 1/16 in. of the washer. Cut the wire off, and spread the resulting coil to about 1/2 in. in length. This will exert sufficient pressure to keep the switch arm in good contact with the studs.

As the adjusting rod slides through the rubber plate *C*, it is necessary to make a connecting link as shown at *H* to preserve the circuit between the rod and the lower binding post. This link is of 1/32 in. brass, as shown in the detail sketch, and is drilled to fit the rod snugly. In the view of the right end of the assembly in Fig. 4, this link is shown plainly.

The terminal posts used on this tuner are of the style shown in *B* on Fig. 5. On the ends of the running rods on plate *C* two binding posts are placed, where the electrical conditions only require one. The second post adds a symmetrical appearance, as well as strengthens the joint at this point.

To sum up the advantages of this tuner: (1) the secondary can be easily changed for various sizes of units; (2) it can be separated widely from the primary to obtain extremely loose coupling; (3) the adjusting rod controls both the distance of the secondary from the primary, and also the number of sections cut in, allowing two important operations to be simultaneously performed.

The one sliding contact on the primary is ample for all purposes. A binding post is placed at each end of the primary for convenience in wiring, and to allow a greater range of coupling, by selecting the post near or away from the secondary for the ground connection.

Tracing the circuit of the primary, we find that the oscillations enter through the terminal *B*3, from the antenna, thence to the slide contact via the sliding contact rod; then to the primary winding and out through either terminal $B1$ or $B2$, whichever is used. In the secondary, the circuit is, starting at the terminal $B5$, through the connecting link; the adjusting rod J, thence to the switch arm; from this to the studs, and through the sections included by the switch arm; then through to the running rod L, and to the terminal $B4$ on the plate.

In winding the enameled wire on the primary and secondary, plenty of shellac should be used, so that the wire will adhere tightly. On the secondary, it is advisable to first shellac strips of soft paper before winding the wire, as the wire will cling to the paper much better than to the wood. The line along which the sliding contact travels can be easily scraped clean with a knife. Avoid irregularities in winding, and do not cut or kink the wire.

AN ALTERNATOR FOR DIRECT PRODUCTION OF ELECTRIC WAVES FOR WIRELESS TELEGRAPHY

DR. R. GOLDSCHMIDT

Summary.—Realizing the extreme difficulty of designing a high-frequency alternator on the usual lines, the author has devised one like an induction motor in which the currents in the rotor and stator react on the stator and rotor so as to produce currents of the frequency desired.

In wireless telegraphy, alternating currents are required with a frequency of at least 30,000 periods per second (10,000 meters wave-length), but it is desirable to produce frequencies of 100,000 cycles and more. However, not only high frequencies but also considerable output is required for telegraphy over long distances, in order to secure a high degree of certainty (say, the same as with cable telegraphy), and for wireless telephony; besides, for telephony perfect uniformity of the waves obtained from the generator is important.

The spark and the electric arc can produce only limited power, and are not quite so steady as desirable for telephony. Therefore, for many years engineers have tried to design machines capable of producing electric waves without spark and arc, machines the output of which only depends on their dimensions and which could be built up to any size like ordinary dynamos.

High frequency and considerable output are two contradictory conditions, as a simple consideration will make obvious. The circumferential speed of the revolving part will naturally be made as high as possible. For the sake of example, the circumferential speed may be 80 meters per second, a figure which is very high for an ordinary turbo-dynamo. If we wish to obtain 30,000 cycles per second, the pole pitch (t in Fig. 1) must be made

$$t = \frac{80 \times 1{,}000}{2 \times 30{,}000} = 1.33 \text{ mm.}$$

The pole-pitch t is the sum of the dimensions of the iron b, the copper a and twice the insulation c. Considering that there are quite high voltages to be dealt with, it is out of the question to make the total insulation less than 1.33 mm. (single thickness 0.025 in.), so that no space would be left for the active material, copper and iron. Though we might increase the circumferential speed to double that in our example or more, we shall still not be able to produce much power. Besides, such speeds would not allow us to increase the dimensions of the alternator axially beyond a few inches; we should be forced to make only quite narrow machines. The depth of slot (e in Fig. 1) is limited by the leakage which one must be careful about with small pole-pitches and high frequencies. The leakage is not only dangerous on account of its saturating the iron, but the iron losses and the voltage will be raised by it. A mechanical disadvantage of the small poles is the proportionately small air space between rotor and stator.

Recognizing these difficulties, the author has invented a special method for the direct production of high fre-

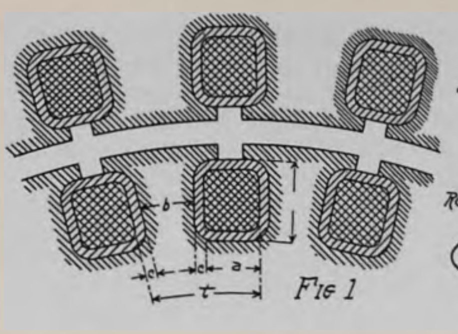


FIG 1

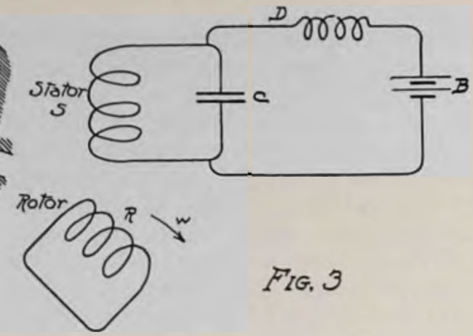


FIG. 3

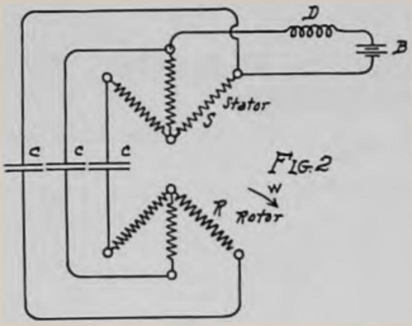


FIG. 2

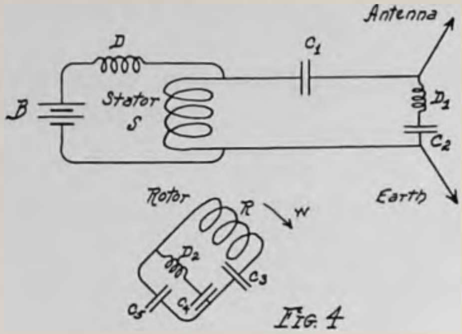


FIG. 4

quency as well as high output. This system has proved successful in practical use.

Referring to Fig. 2, S is the stator, R the rotor of a machine built like an alternating-current induction motor. The slip-rings of the rotor are electrically connected with the stator terminals. We excite S or R or both of them with continuous current from the battery B, the latter being protected against alternating current by the choking coil D, and let the rotor revolve at an angular speed w. In Fig. 2 rotor and stator are separated from one another by the condensers C, so that the continuous current only flows in S. In R currents are induced of the frequency f, corresponding to the number of poles and revolutions. These currents flow through C into the stator winding, and set up a revolving field, rotating at the angular speed w, its connections being such that its direction of rotation is opposite to that of the rotor. Consequently a relative velocity of $2 \times w$ between field and rotor is reached, and the currents produced in R have the frequency $2 \times f$. These currents flow back into the stator and create in the rotor $3 \times f$, and so on. Through automatic transformation infinitely high frequencies ought to be obtained.

The method has been considerably simplified, the form adopted in practice being indicated in Fig. 3. Rotor and stator carry single-phase windings. Rotor R is short-circuited on itself, whilst the stator is short-circuited for alternating current only by the large condenser C.

S being excited with direct current, currents of the frequency f will flow in R. Consider now R as the primary, and split up the alternating field due to the rotor current into two components revolving synchronously relative to the rotor, but in opposite directions. One of these components, that revolving backwards, will be stationary and forms the rotor reaction on the field produced originally by the continuous current. The second component has the speed $2 \times w$, and induces in the rotor currents of the frequency $2 \times f$. Splitting up these currents again into a "reactive" and an "active" component, the latter creates in the rotor currents of $3 \times f$ periods. Finally, also, in this case infinitely high frequency should be obtained automatically. Comparing Figs. 2 and 3, the chief difference is found to be that the electric energy is taken back from the secondary to the primary in one case by conduction, in the other case by induction.

Considered superficially, it might appear that by this method only "higher harmonics" will be produced, *i.e.*, comparatively small superposed waves, existing as a by-produce, as in ordinary alternating machinery through non-sinusoidal fields, or through the reaction of field and armature of single-phase alternators on one another. This is not the case if care is taken that the non-utilized lower frequencies can flow in perfectly short-circuited paths, and that only the highest frequency passes out into the antenna. Then inside the machine an automatic transformation of the lower frequencies takes place with a very considerable efficiency, the energy increasing together with the frequency, as at each step of increase fresh mechanical power is transformed into electrical and a new impulse obtained. Without a good short-circuit for all the inactive frequencies the currents of higher frequency would decrease more and more.

Stator and rotor winding might be compared with a stationary and a revolving mirror between which the electric power is reflected like rays of light. Due to the movement of one of the "mirrors," the frequency rises at each reflection, and the smaller the absorption of power by the mirrors themselves (*i.e.*, the less the circuits are damped) the higher the efficiency. Perhaps the alternator might be called a "reflection alternator."

It may be mentioned that the reactive and the active fields nearly compensate one another, and that only the last field (highest frequency) exists fully. Consequently only the latter causes the full iron losses. This is one of the advantages of frequency transformation in a single machine.

If we wish really to short-circuit a winding for alternating currents, this must not be done by a simple wire, but by means of condensers, compensating for the self-induction of the winding itself.

Fig. 4 shows a typical plan of connections for the machine, illustrating the principle of tuning and filtration. In reality, however, considerable simplifications have taken place.

As an example, suppose we wish to produce four times the frequency which the machine would deliver without the frequency being artificially raised. The stator S being excited with continuous current from the battery B, the rotor currents of the frequency f pass over C_3, D_2 and C_4. The condenser C_3 compensates the self-induction of the rotor, whilst D_2 and C_4 are in resonance at f periods. The stator currents with $2f$ cycles flow across C_1 (compensating the self-induction of S), D_1 and C_2. D_1 and C_2 are in resonance at $2f$ periods. The rotor currents of the frequency $3f$ pass across C_5, this condenser tuning the rotor for this frequency. The frequency of $4f$, which we wish to utilize, may be taken from the points a and b, perfectly pure. D_1C_2 being out of tune for $4f$, only a very small current of this frequency passes through this shunt to the antenna, but as D_1 and C_2 are tuned for $2f$, practically no voltage at this frequency exists between a and b.

Fig. 5 represents the first machine of this kind. It has been working since April, 1910, at the Eberswalde Radio-Telegraphic station of the C. Lorenz Telegraph Co., in Berlin. The output of the machine is 12½ k.w. at 10,000 meters wave-length and 8 k.w. to 10 k.w. at 5,000 meters. There is no difficulty whatever in building machines for any desired output up to 80 k.w. and more, and a wave-length of 3,000 meters can be easily obtained. The efficiency at 10,000 meters is about 80 per cent. A special advantage of the alternator is that a great many frequencies may be obtained by simply closing and opening switches. The finer grading of the frequencies may be effected by a special method if required.

The Lorenz Company greatly assisted me in making the invention a success, and the Company own my German patents.

Experiments have been made to show that the temperature of a magnet has something to do with its power to attract and hold. By placing a magnet in alcohol Mr. Pictet found that if the unit 57 measured the pull at +30 degrees C, the attraction when the temperature was at —103 degrees C was 76, thus showing a decided increase in power at a low temperature.—*Popular Electricity*

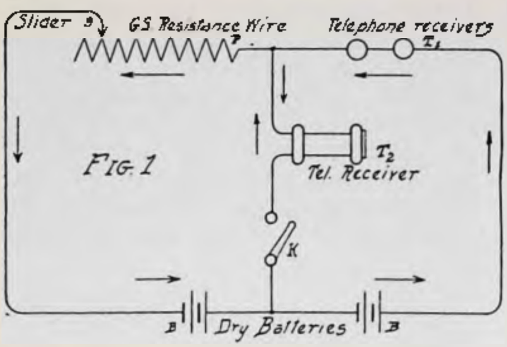
MEASUREMENT OF INTENSITY OF WIRELESS SIGNALS

S. P. YOUNG

To accurately measure the intensity of received wireless signals, an extremely sensitive and expensive galvanometer is usually required, an instrument which is beyond the means of most amateur experimenters in the wireless field. A cheap and sensitive apparatus may be easily constructed, however, to measure the intensity or strength of these signals.

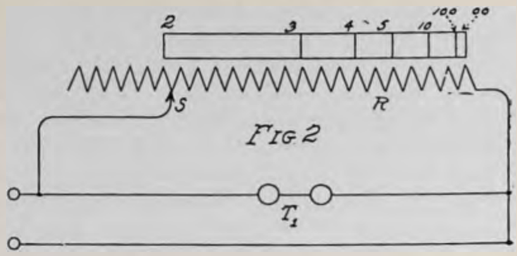
This apparatus is used in conjunction with the telephone receivers of the ordinary receiving set and the principle of the scheme rests on the well-known fact that the ear, although it cannot distinguish how many times one sound is louder than another, can always perceive when they are equal in strength or loudness.

Therefore, in applying this principle the signals as they are heard in the telephone receivers are reduced in intensity by shunting resistance around the receivers till they become just barely audible, and the real intensity is read off on a scale attached to the resistance. In this way, the unit of intensity becomes a sound just audible, and thus by obtaining the number of times the signals from two or more different stations are respectively louder than this unit we are able to compare them with each other.



In order to construct an apparatus for the above purpose, wind one layer of German silver resistance wire on a piece of wood turned to about 1 in. in diameter, and fix some form of slider on it to vary the resistance. The total resistance of the wire should be exactly equal to the resistance of the telephone receivers used on the receiving set for which the apparatus is intended.

To get this resistance exactly, we should use the following directions, explained by Fig. 1.



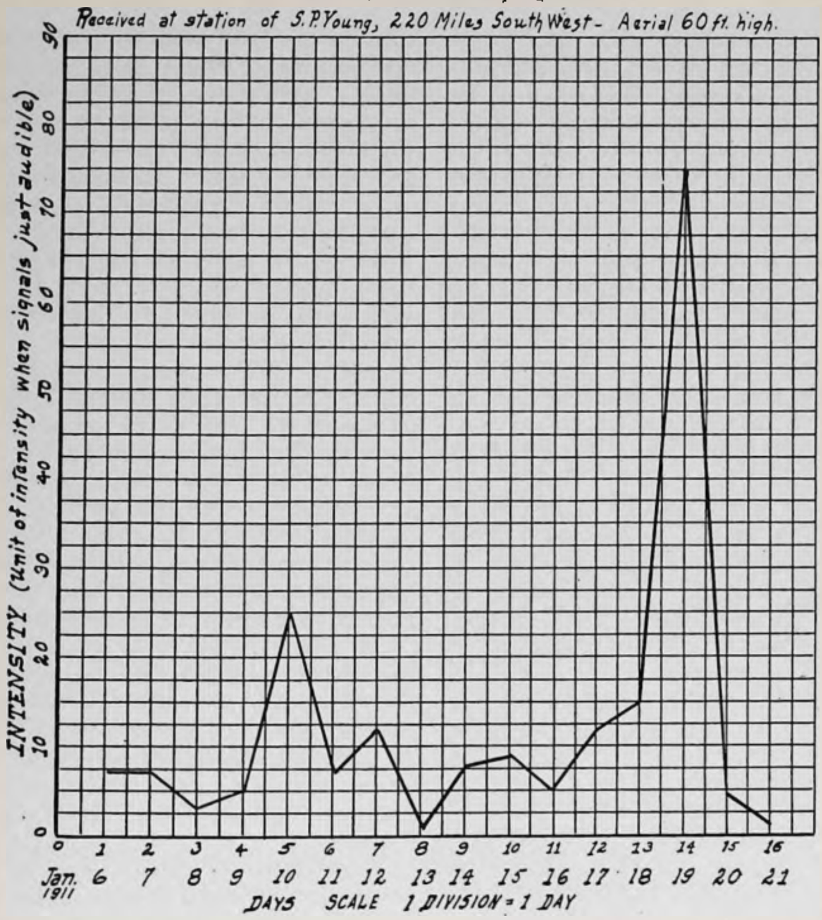
T^2 is any telephone receiver that can be temporarily procured, such as the receiver from the telephone line, for it is only needed a minute or two. The dry batteries *B*, *B*, two in a set, should be tested with a battery ammeter, so as to be sure they give equal currents.

Connect up as per diagram, placing the slider *S* on the resistance wire *R*, and listen in the receiver T^2. Then close the circuit at *K* and a sound will be heard. The slider must now be moved along *R* to such a position that no sound is heard in T^2 when *K* is opened and closed. The resistance wire in circuit will now be equal in resistance to the receivers T^1.

Disconnect the apparatus and mark the position on the resistance where the slider finally came to rest, 2. Then construct a scale of cardboard making it equal in length to the distance between 2 and the right end of the resistance. This right hand end is to be marked ∞ (infinity). To get intermediate numbers on the scale divide the scale in half and call the middle point, 3; take one-third of the whole scale length, starting from the infinity end and mark this point, 4; ¼ is to be marked 5, etc. (see Fig. 2).

Connect up the receivers as shown by diagram and connect the receivers also with the wireless receiving apparatus in the usual way. Listen for some station and when one is heard run the slider *S* along the resistance toward the right. The signals will become fainter and will finally become too weak

Intensity of Received Signals from Marconi Station at South Wellfleet, Mass.



to hear. The reading of the scale corresponding to the slider position where the signals are just audible will be the strength or intensity of the signals being received from the above station. It will be noticed that the scale begins at 2 instead of 1; but a signal which can just be heard in the receivers, and which cannot be heard even with the slider down at 2, is a signal with an intensity of 1.

With a device such as this many interesting experiments may be performed. Readings can be taken on outgoing steamers, and the effect of distance on strength of signals is strikingly demonstrated, or readings may be taken of signals sent from land stations at a fixed distance to ascertain the effect of sunlight and darkness and the effect of weather on the transmission and reception of wireless waves.

Fig. 3 is the result of a series of readings taken by the writer, and shows how the atmospheric conditions affect the transmission of signals from the Marconi high-power station at Wellfleet, Mass. The receiving station where the readings were taken is located at Montclair, N.J., a distance of 220 miles from where the signals were radiated.

The British Radium Corporation has recently had a safe made for holding radium to the amount of 100 lb. valued at $5,000,000,000. A 3 in. wall of lead is built inside the steel shell to prevent emanation and means are provided for collecting the emanation before the safe is opened.—*Practical Engineer.*

CONCERNING SECOND-HAND ENGINES

F. L. BAILEY

To just the average man who is no steam engineering expert, and contemplates buying a second-hand engine, the following instructions should prove useful in enabling him to obtain an engine which will successfully fulfill his purpose. In the first place, he should know well the character of work which the engine will be required to perform. As there are many classes of loads so are there many classes, or types, of engines, each one of which will work much better in its own sphere; for instance, it would be about as foolish to rig up a marine engine to drive a saw-mill as it would be to harness Dan Patch to a 2-ton truck. There are several kinds of work which make similar loads: for example, a marine engine would be entirely suitable to drive a centrifugal pump or blower, also an engine which would run a rock crusher efficiently would be equally well adapted to driving a concrete mixer or corn shredder as the nature of the loads are similar. Loads and engines suitable may be divided generally under the three following heads:

1st. *Steady loads; constant speed.*—Example: blowers, pumps, liquid agitators and the like. Engine should be compound, heavy flywheel and governor not essential, engine need not have large over-load capacity.

2d. *Variable load; constant speed.*—Under this head comes most of the everyday machines: saws, woodworking machines, grinders, machine tools and a score of others. Just whether a compound engine should be used or not will depend upon the local conditions. If the load is heavy and steady as in a flour mill, then use a compound engine by all means; but, if, on the other hand, the load is in general light or subject to great fluctuations, the simple engine will usually be preferable. Engines for this class of work should have rugged moving parts and heavy flywheels. A large overload capacity and governor are also absolutely essential.

3d. *Variable load and variable speed.*—Example: elevator engines, derricks, hoisters and locomotives. We see for this work there will be much stopping and starting, hence the advantage of double cylinders. Compounding will in general, not be of any advantage, as the loads and speed vary too much. No governor is used. Engines should have large overload capacity, and in many cases may have to be reversible.

As all second-class engines are apt to have unseen faults, the following instructions are given to detect the most prevalent of them:

Leaky slide valve: Set the engine on dead center, then turn it slightly back against the direction of rotation, in order to close the opening caused by the lead of the valve. Open both cylinder cocks and crack the throttle valve. If steam escapes from the cylinder cocks or the exhaust, and continues to do so when the engine is rocked slightly back and forth, you may be sure that the valve is leaking.

To determine the point of cut-off: Turn the engine back from dead center against the direction of rotation, first slightly opening the throttle and cylinder cocks. At the position where the steam begins to oppose your movement and to escape from the cylinder cock is the point of cut-off.

To determine if piston rings are leaking: Set engine on dead center, close exhaust valve, if fitted, if not, plug up the pipe with a piece of wood, open cylinder cock on end of the cylinder away from the piston, leaving the other closed, then slightly open the throttle. If steam escapes from the open cylinder cock, either slide valve or piston is leaking; if it ceases to escape when the engine is turned slightly backward, the valve is not at fault, hence it was the piston that was leaking. If it continues to escape when the engine is turned backward, the piston will have to be removed and examined separately.

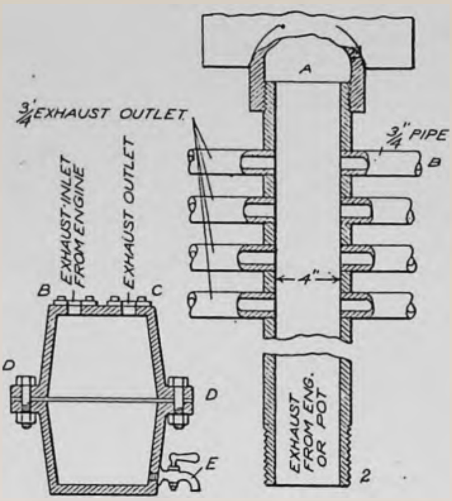
A rough, and at the same time, a pretty accurate idea as to whether the valve is properly set, may be obtained by cracking the throttle and turning the engine slowly in the direction of rotation, noting the escape of steam from the open cylinder cocks. If the steam starts to escape slightly before the piston reaches the end of the stroke, the valve is properly set. This should be the first test made, for, if the valve is not set right, none of the above tests hold good.

I just want to say a final word regarding the power of an engine. Always remember that when a man tells you that his engine is, say 10 h.p., that it amounts to about as much as when the horse dealer tells you that a certain horse is 1 h.p. I don't believe that there is an engine manufactured in the United States but what will develop its rated power on a brake test. But do you know that a large number of companies guarantee all engines to develop double their rated power? The power of an engine depends directly on the pressure, speed and size of the cylinder, so don't expect a 6½ in. x 9 in. cylinder engine, running 250 per minute on 130 lbs. pressure, to do the work of a 7¼ in. x 10 in., running at the same speed on the same pressure, although both engines may have been rated 10 h.p. The almost universal rule in *small* engines is a ¾ stroke cut-off, so the variation in the per cent. expansion does not amount to so much, and should the engine be large, involving considerable cost, the services of an expert should be secured.

Muffler for Gasoline Engines

In the accompanying illustration is shown a home-made muffler which we constructed for a 20 h.p. gasoline engine, writes J. A. L. in *Practical Engineer*. It gives effective service in eliminating the sharp, penetrating quality of the exhaust noise without causing appreciable back pressure. The sides of the main 4 in. exhaust pipe are drilled and tapped for ¾ in. pipe; screwed into these holes, of which there should be from 10 to 16, according to the size of the engine, are ¾ in. pipes 6 in. in length. These pipes are attached near the end of the exhaust pipe for a distance of 4 or 5 ft., and a tee is secured at *A* on the outlet of the main exhaust.

In our case, the main exhaust is attached to the engine through a cast-iron exhaust pot, also shown in the illustration. This is made in two sections bolted together by means of the flanges



MUFFLER AND EXHAUST POT FOR GASOLINE ENGINE

shown at *D*, sheet asbestos being used for packing this joint. Exhaust from the engine is attached directly to the inlet, *B*, of this exhaust pot and then the main exhaust pipe is attached to the outlet *C*. The method of fastening these is by means of screw flanges and stud bolts as shown in the illustration. The exhaust pot is 18 in. in diameter and 24 in. high. It is provided with a drip cock to relieve it of any water which may collect at the bottom. The exhaust pot should, of course, be as near to the engine cylinder as possible and attached in such a way as to give the force of the exhaust downward.

The exhaust gases pass from the pot into the main 4 in. pipe and the sound is deadened by taking in air from the sides or letting out the exhaust in such a way as to eliminate the disagreeable noise of the discharged gases.

To keep small particles of dirt and foreign matter from stopping up the spout of an oil can, a correspondent of *Popular Mechanics* uses a sieve shaped like a thimble in the lower end of the spout. Any fine gauge wire can be used for this purpose. This catches all the dirt but does not stop the flow of oil.

Selling goods by demonstration is the most successful policy known. When buying apparatus visit some plant where a demonstration is going on every day.

FOR THE LABORATORY

EXPERIMENTAL HIGH-FREQUENCY APPARATUS—Part II

STANLEY CURTIS

The construction of a high-tension condenser will be taken up in the present article. To some readers it may appear that the author is starting at the finish and working backward, so to speak, in this series of articles. The object of this, however, is to enable those readers who are already in possession of a transformer or powerful induction coil to go ahead with the construction of the high-frequency apparatus without wading through a necessarily long account of the construction of a high-tension transformer.

Strange to say, the high-tension condenser of the average experimental wireless telegraph station is one vital part of the set which receives but little care or thought in its construction. If the experimenter did but know how much energy is wasted in poorly-made and therefore inefficient condensers, he would give this subject rather more attention than he does. In the amateur wireless station, the inefficiency of any particular part of the apparatus is not nearly so apparent as it is in the operation of the instruments described in these articles. Here we are dealing with something from which we may expect to get certain visual results. If any part of our apparatus is not working properly, we are at once aware of the fact through a great reduction in the length and quality of the spark. As the principal use of this apparatus is to entertain and instruct people, it is evident that the various parts should be made with care so that there will be no "hitch" at the critical moment.

The principal defects in home-made condensers are inequalities in the thickness of the dielectric due to air bubbles under the conductor, and a very wasteful brush leakage from the edges of the conductor. Several methods of construction may be adopted to do away with these defects, but for portable purposes the most efficient method, using oil as a dielectric, is almost out of the question. The Leyden jar type using acidulated water as the conductor is equally impracticable and it appears that there is but one method left for us to use. The glass plate with tin-foil fastened on it by means of shellac is a very popular form of condenser among experimenters, but it is also one of the most inefficient. It is practically impossible to get the foil in close contact with the glass by this method, and it is still more difficult to thoroughly dry the shellac between the foil and glass, for the varnish along the edges dries and seals that in the center so effectively that no air can get to it. Drying in an oven invariably produces blisters, and it is extremely doubtful if the moisture is expelled even by this method.

The condenser to be described is simple in construction, very quickly built, and it has none of the defects mentioned above. In addition to this it readily adapts itself to portable use and what is still more important, there is no brush leakage visible in the dark while the condenser is in operation. The conducting sheets are in as near absolute contact with the glass as it is possible to get them, and the adhesive used contains no moisture whatever. The single disadvantage, if it can be called one, lies in the fact that heat in any considerable quantity will loosen the foil from the glass. For the simple reason that the common causes of heating in condensers are absent in this one, no trouble may be feared on that score.

The size or capacity of the condenser will depend on the transformer, its voltage and the current in the secondary. The specifications here given are for a

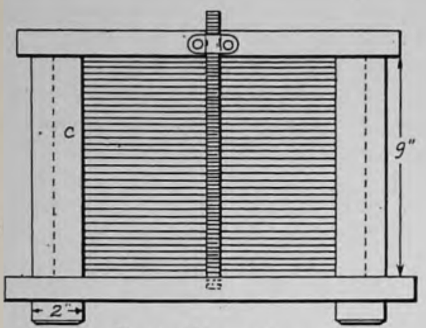


Fig. 6 Elevation-Side

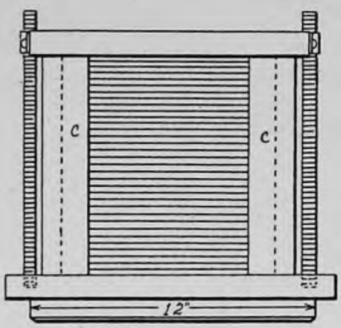


Fig. 7 Elevation-End

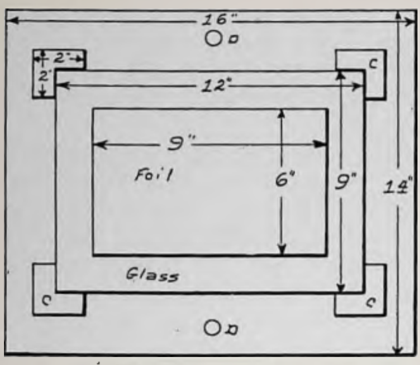


Fig. 8 Plan- cover removed

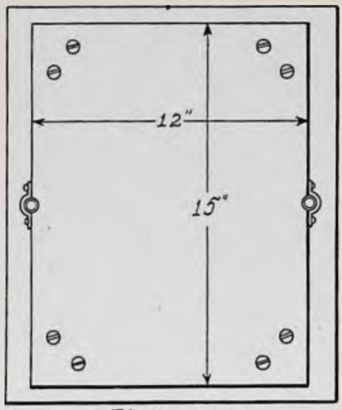


Fig. 9 Plan

Condenser

Stanley Curtis 1911

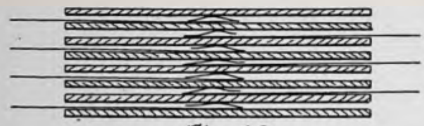
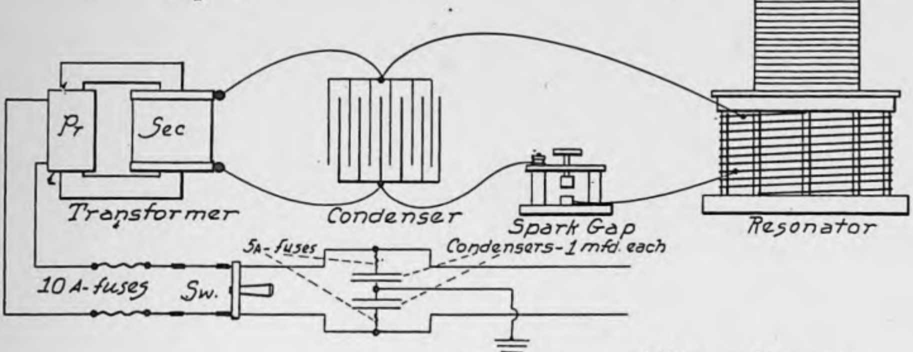


Fig. 10

Fig. 11

Fig. 12



Wiring Diagram

condenser to be used on a ½ kw. transformer having a secondary potential of not more than 20,000 volts and operated on a 60-cycle alternating current circuit. If a higher secondary voltage is used, the condenser should be made up in two separate units and these two units connected in series.

Thirty-six pieces of window glass, each 9 x 12 in., will be required. They should be carefully selected and it is imperative that they be free from air bubbles or other imperfections. Plates of as nearly the same thickness as possible should be selected. The extra thick glass is desirable, and the minimum thickness allowable is ⅒ in. If this thickness, or heavier, cannot be obtained it is advisable to make two units and connect them in series as suggested in the last paragraph.

A moderately warm oven, several soft cloths, a small lump of pure beeswax and a good firm table with cloth covering are necessary for the building operation. Three pounds of heavy tin-foil should be obtained and cut into sheets 6 x 9 in. The heavy foil comes in 1 lb. packages, each containing about five strips 6 x 48 in. In purchasing the foil it is advisable to obtain one package and count the number of strips in it. The condenser will require 72 pieces of foil and the number of pounds necessary may thereby be readily computed. The author suggests this because in various localities the foil may differ in thickness.

The glass plates are to be carefully cleaned and polished with a soft cloth dipped in alcohol. Crumpled newspaper will further facilitate the polishing process. The sheets of glass are then placed a few at a time, on edge, in the oven, which should be but moderately hot to prevent cracking. When the first sheet has become sufficiently hot to readily melt the beeswax when touched by it, remove the glass and lay it on the cloth covering of the table. Warm the cloth slightly and touch the glass with the beeswax. Rub the cloth briskly over the plate until it is literally painted with an exceedingly thin coat of wax. Immediately place a sheet of tin-foil in the center of the glass and rub it out with a circular motion, using the cloth and commencing at the center and working out toward the edges. The thinner the coating of beeswax, the better will be the result up to reasonable limits. If there is just sufficient wax on the glass, the foil may be rubbed in to such an absolute contact that it may be polished with the cloth. If the work is done quickly the other side will still be hot enough to melt the wax and it is to be treated in the same manner. When the condenser is picked up from the table, a spark from ½ to ¾ in. in length may be drawn from one of the foil sheets by presenting the knuckle to it. Before the plate is cold, melted beeswax should be painted over the edges of the foil by means of a soft brush. This appears to absolutely prevent any appreciable brush discharge from the edges of the foil while the condenser is in operation, even when a comparatively high voltage is used. The entire thirty-six plates are to be coated on both sides with foil and then stood in a cool place for the wax to harden.

The method of mounting will depend largely upon the use to which the apparatus is to be put. For strictly portable use, a strong wooden case in which the condenser may be sealed is desirable. For laboratory use and especially where the condenser is to be used for experimental purposes where it requires frequent and extensive adjustment, the container here described will be found most convenient. The stock may be any dry and well-seasoned wood. Whitewood is easy to work and it takes stain very nicely. The wax finish is by all means preferable to a varnish one in this case.

Figs. 6 and 7 give an idea of the general appearance of the assembled condenser. The base is built up from ⅞ in. stock and it should be fitted with battens across the bottom as suggested in the illustrations. The corner pieces *C*, are preferably cut from solid stock, although not necessarily so. These pieces are secured to the base by means of screws, care being taken to see that they are truly perpendicular to the base. The drawing of the top of case is self-explanatory.

Before assembling the plates in the container, one hundred and fifty-two ½ in. squares should be cut from ⅛ in. rubber packing. One of these squares is placed in each corner of the base inside the corner piece, and a plate of the condenser placed on them. Four more rubber cushions are then placed on the glass and another plate added. This is continued until the plates are all in position and separated ⅛ in. by the rubber packing. Pieces of packing are placed on the top plate and the wooden cover fastened in position with screws.

Connections to the plates are made through strips of No. 36 phosphor bronze sheet. The strips are cut ¼ in. wide and 6 in. long. One end is bent over for a distance of 2 in. and the piece bowed as suggested in Fig. 11. The strips are inserted between plates and the spring makes firm contact with both pieces of foil. A piece of No. 14 spring brass wire is wound closely on a ⅜ in. rod to form the close spiral spring into which the ends of the bronze strips are inserted. Two of these springs are required and they are secured in position by inserting the lower ends in holes bored in the base and fastening the upper ends under the straps on the top or cover board as shown in Fig. 6. The upper ends of the springs project for a distance of 1 in. above the retaining strap and thus afford a ready means of connection for the secondary ribbon which is slipped between turns.

In placing the connecting strips in position, great care must be taken to see that the positions are alternated on either side so that the plates of the condenser are connected in multiple. The scheme is suggested in Fig. 10, and by following this diagram closely, no mistake can be made. It is obvious that any number of plates may be cut in or out by merely placing in or withdrawing the requisite number of connecting strips.

A number of methods of connections for the oscillation circuit may be used, but the one shown diagrammatically in Fig. 12 has given the author best results. In this the condenser is shunted directly across the secondary terminals of the transformer and the spark gap is in series with the helix and the condenser. One terminal of condenser is connected directly to the top turn of the resonator primary while the other connection, that from the spark gap, is moved up or down the turns of the helix until best results are obtained.

The operation of a high-potential transformer in connection with a circuit in which oscillations are set up is attended with a very real and serious danger to the wiring of the house and to the lighting company's transformer which supplies the line, unless a protective device is installed to prevent the "kick back," as it is called, from rushing back over the line. Cases are on record where fires have been caused by this very thing and in places where the house wiring in other respects complies fully with the Underwriters' requirements. The high voltage surge rushes back along the line wires until it strikes a place where the wires are sufficiently close together to permit a spark to pass from one side of the line to the other. This spark forms a path of comparatively low resistance, and the main current rushes across the path in the form of an arc which may readily set fire to inflammable material before a fuse can have time to melt. It is principally for this reason that the lighting companies object strenuously to having their service connected to experimental wireless telegraph apparatus, for the kick-back has, in several cases, been known to break down the insulation of the street transformer, and in some instances to burn it out completely, thereby placing the entire district which is being supplied by that particular transformer in total darkness.

A device which will afford ample protection to the line and transformer is readily constructed and installed, and every experimenter should by all means place this protection on his line if he is using current from the lighting mains. The device consists of a pair of 1 mfd. condensers connected in series and the two shunted across the line immediately in back of the transformer. The neutral point of the condensers is connected to a good ground which should be other than the one used for grounding the aerial if in a wireless telegraph installation. These condensers may be purchased from dealers in telephone supplies, or they may be made in the laboratory. The position and connections of the condensers in relation to the apparatus under discussion is shown in Fig. 12.

The next article will take up the construction of the transformer used in connection with the author's set of apparatus.

(To be continued)

HOW WIRELESS DETECTORS WORK

ERNEST C. CROCKER

When the magnetic waves sent through the air from a distant sending station pass by the "antenna" of our receiving station, there is set up in it an alternating current, which, if made evident to our sight or hearing, allows us to "read" the message which is being sent. This alternating current acts exactly the same as any other alternating current of the same strength and rapidity of alteration and acquires no new properties on account of its aerial journey, and we will therefore consider how any feeble, rapidly alternating current may be detected.

The only practical instrument which has yet been devised for the detection of very feeble electric currents is the telephone receiver, but this is unable to detect rapidly alternating currents. Fortunately, there are many ways of making the "wireless" currents operate a telephone receiver and any apparatus used for this purpose is called a "detector." Many principles are depended upon for the working of the different detectors, but we shall here consider only the more important or instructive of these and without regard to their history or development.

Received wireless currents may make themselves evident by virtue of properties that any electric current possesses (such as heating), by special properties which they possess because they are rapidly alternating currents, or, be converted into direct currents so that they may operate a telephone receiver directly, and we shall consider how this is done—in the order mentioned.

Any current heats the conductor which carries it, and if we have an extremely fine wire for our conductor, even a current as minute as will be produced in an antenna by a distant source of magnetic waves will heat the wire appreciably. When a wire is heated, its resistance is changed, and changed to such an extent that the heating produced by a "wireless" current in a very fine wire will vary the resistance enough to make a sound in a telephone receiver which has a current flowing through it which must also pass through this little wire.

Upon this principle many detectors have been constructed, but the most conspicuous is the so-called "hot-wire barretter," of Fessenden. In this instrument we have a short length of exceedingly fine platinum wire, and this wire is so very fine that it warms up and cools down at a rate fast enough to follow a high musical note. Other detectors depending upon this principle but differing in construction, are: the carbon granule "coherer," the detector using carbon knife edges with a piece of steel across them, and the "liquid barretter." In the two first mentioned we have a loose contact between carbon and steel, and the resistance of the contact is varied by the heating produced by the current of the antenna; and in the second we have an exact parallel to the hot-wire barretter with a thin thread of liquid instead of the platinum wire. The use of liquid instead of platinum makes the detector several times more sensitive and also self-restoring in case a current strong enough to rupture the little thread is sent through it.

When we have a piece of tellurium in contact with a piece of some other metal, and vary the temperature of the contact by even a small amount, we have an appreciable "thermo" electro-motive force set up by this "thermo-junction," which current may work a telephone receiver or any other sensitive instrument. Now, if we have a "heater" which is traversed by a current from the antenna (the received message) and have this heater (a piece of wire easily heated) close to a thermo-junction of great sensitiveness, it is possible to detect the received oscillations by the sound in a telephone receiver whose terminals are connected to the terminals of the thermo-junction—in this case no battery is used. The thermo-electric detector of Collins is said to work directly on this principle. The silicon detector was at first thought to depend upon this principle but afterward this was found not to be the case.

The Marconi coherer was also thought to depend on thermal action; the filings were considered to be welded, or fused together (thereby enormously lowering the resistance) by the heating action of the current. A much better explanation, however, is that this detector depends primarily upon static-electric attraction, and that the filings cohere by virtue of their electrical charges attracting them toward each other and thereby closing up the gaps. With this detector we are able to use a recording device, and this is sometimes advantageous. The coherer's drawbacks, however, keep it from competing with many of the other forms of detector, and it is now very little used.

Feeble alternating currents can also produce magnetic effects and use has been made of these in the "magnetic detector" of Marconi and the "heterodyne receiver" of Fessenden, as well as in several types of instrument useful in the laboratory but not as yet adapted to practical receiving.

It takes an appreciable time to magnetize a piece of iron, and the property which iron possesses which causes this time to be taken is called "hysteresis"—it is a sort of magnetic inertia or opposition. The effect of this hysteresis can only take place while the iron is being magnetized or is being demagnetized, just as inertia is only felt when we are starting a heavy body moving or are stopping a moving heavy body. Now it happens that when a piece of iron is within the influence of a very rapidly alternating magnetic field, that it loses a greater part of its hysteresis, only to take it up again when the magnetism ceases.

If we have a band of iron wire continuously moving in front of, and from one to the other, of the two poles of a magnet, the hysteresis of this iron band will prevent its being magnetized to any great extent—in fact, it is as though the iron band were a long train going continuously from one pole to the other (always in the one direction like an endless belt) and that the magnetism wanted to jump to the train and ride along so that it could jump off at the other pole, and that the hysteresis were a repelling force which tried to keep the magnetism from jumping onto the moving train. If we should, for an instant, stop this repulsion (hysteresis) the magnetism would make a great rush and a large amount would be momentarily carried by the wire. Now this is just what can be done if we have a coil of wire wound on a spool and place the spool so that the iron band passes through it while going between the poles of the magnet, and pass a rapidly alternating current through the wire on the spool. The feeble antenna current (the sending station's power that actually gets to the receiving station) is strong enough to do this if we connect the antenna and ground wires to the terminals of the wire on the spool. Summing up these facts, we see how the received oscillations are able to make the magnetism vary in a band of iron wire and if we put a second coil on the spool and connect its terminals to a telephone receiver we get ticks or buzzes due to the current which is induced whenever we vary the magnetism which is passing through the coil of wire, just as in the secondary of an induction coil.

In the case of the "heterodyne" receiver we have an entirely different effect; in fact, the effect is the same as in a common telephone receiver,—a field magnet making a diaphragm vibrate on account of a periodic attraction between the two. The diaphragm here, however, is not a piece of sheet iron but is a non-metal diaphragm carrying a coil of wire, traversed by a high-frequency current generated by a small, nearby dynamo; and the field magnet is a similar coil held rigidly and traversed by whatever currents are induced in the antenna. When we have two magnets facing each other and of opposite poles (one North and the other South) there is attraction, and if similar poles, repulsion. It makes no difference how fast the magnetism of these poles may be reversing so long as both poles change simultaneously, if they are of opposite signs there is a continuous (although of course vibratory) attraction between them. Now, if in our heterodyne receiver the magnetism produced in the field magnet by the received alternating current should vibrate with the same pitch and in the same phase as that produced in the diaphragm coil by the dynamo, there would be attraction (or repulsion) between the coils and we would have something similar to the telephone receiver. In practice this receiver demands the greatest of care in operating, for if the frequency of the two magnetisms should vary by even 1/10,000 of one per cent., in rate of vibration we may find inoperative. This is one of the most wonderfully selective devices ever made and fine work has been done with it at the Brant Rock station.

We have seen that an alternating current can produce numerous effects by its heating, magnetic and static properties, but by far the greater number of stations use a method of detection which does not depend upon these, and in this case the alternating current is transformed into a direct current and acts directly upon a telephone receiver. This transformation of alternating current into direct is called rectification, and is usually possible when we pass the alternating current through a "valve" which lets it pass readily in one direction and only with difficulty in the other. In order to understand how an electric valve works, we must consider the nature of electricity itself and of the constitution of matter.

According to the best recent theories, there is a definite negative particle of electricity called an "electron," and the entire negative charge on a body is due to the number of these little "atoms of electricity," which the body contains. The positive electricity (and here, "positive" and "negative" are names given years ago, before its real nature was understood and have no more meaning than "A" and "B" electricity) seems to be intimately connected to, and inseparable from, "matter." The little negative particles are not considered as of the same kind as the many times larger particles of matter, and, indeed, are some 1,700 times smaller than the smallest particle of which we know (the hydrogen atom). On account of the smallness of the electrons we should expect that that they would enjoy special freedom which is forbidden their mates, the more limited positive charges, and this exception is abundantly gratified.

A current of electricity is a flow of "electrons," just as a current of water is a flow of drops, and the electrons move through the spaces between the particles of matter (atoms and molecules) much as drops of water move through a pipe. In the case of an arc lamp we have two rods of carbon separated a quarter of an inch or so of air, but in one respect the current flows as though the air-gap were not present—there is a stream of electrons darting across this air-gap and this is all that is necessary in order that we have a current.

One interesting fact presents itself when we try to make an arc between carbons and that is that an arc in air is impossible unless we have a potential greater than 39 volts. Thirty-nine volts seems to be the toll that the electrons demand before they leave a piece of carbon to make an aerial voyage. If we have one electrode made of carbon and the other of a metal like iron, we shall find that when the current flows one way that the toll is 39 volts, as before, but in the other way it is only 10 or 12 volts. The electrons demand different amounts of coercion to make (and in some cases, opposition to keep them from) leaving different substances.

If we have two dissimilar substances, like silicon and metal, in contact, the current flows in one direction with the greatest readiness while it may take a considerable voltage to make it travel in the opposite direction. Very many detectors have been made which work upon this principle, and among them are all the "solid rectifiers," such as silicon, perikon, galena, ferron, etc., the "vacuum valve" of Fleming, the DeForest "audion," and the electrolytic detectors. In the case of the "vacuum valve" and the "audion," we have a piece of very hot carbon or metal (a little lamp filament heated by a battery) close beside a cool platinum plate, and this is put into the circuit with the platinum plate and the filament as the electrodes. The current in this case can flow readily from the hot to the cold electrode but not in the reverse, the current leaving hot metal more readily than cold.

A solder that will fuse at a low temperature and used in uniting soft metals is made by adding three drops of mercury to each ounce of common solder.—*Penberthy Engineer and Fireman.*

The man who cultivates the belief that the world lives by humbug soon learns to say "and so will I."

HOW A MAGNETO MAKES ELECTRICITY

The Principles Involved and Method of Operation Explained and Illustrated. How Sparks are Produced Mechanically for Ignition Purposes—Part IV

P. S. TICE

WITHOUT EXTERNAL TRANSFORMER— Type "D"

In this system, a wiring diagram of which is shown in Fig. 15, there are, properly speaking, no primary and secondary windings. That is to say, while there are two windings, and there is, therefore, a certain amount of construction similarity between the parts of the systems classed as types "C" and "D," the actions are dissimilar, in spite of the similarity of the descriptive terms applied to the several parts of each system. Referring to Fig. 15, it will be noted that two windings are placed upon the armature core, but separated and insulated from each other. One end of one of the windings, shown in light line, is connected to the revolving distributor arm as in system type "C." The other end is electrically connected with one end of the second winding, shown in heavy line. The heavy line winding, commonly called the primary, has its ends connected to the circuit breaker points, one of which is insulated and the other "grounded," in such a manner that when the breaker points are in contact any current which may be induced in the winding will be short-circuited upon itself.

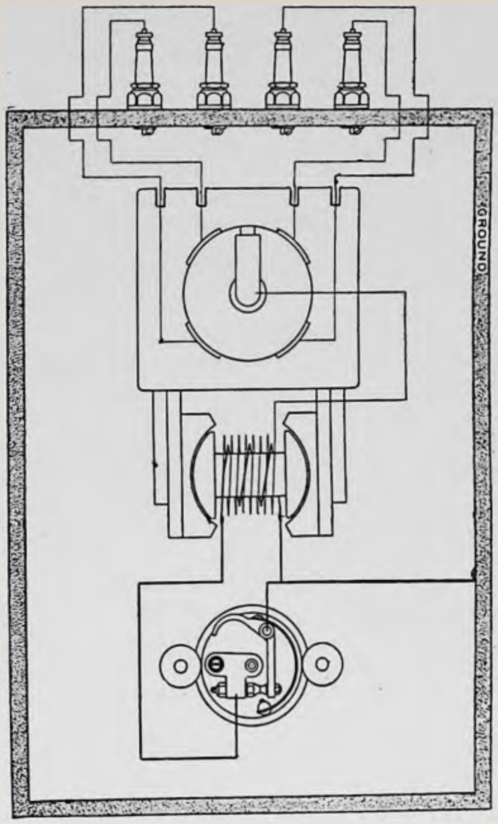


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Fig. 15. Wiring diagram of Type D systems (without external transformer)

In the system type here shown, an electric pressure is induced in both the armature windings at the same time. However, that induced in the so-called secondary, in light line, is insufficient in itself to cause bridging of the plug gaps. But, at the point of maximum induction in the windings, the so-called primary circuit, here shown as short-circuited upon itself through the circuit breaker, is opened by the roller cam, and the electric pressure existent in it is, by virtue of the wiring connections, added to or impressed upon that in the light-line winding, and the two pressures acting together cause the plug gaps to be bridged. As shown by the wiring connections through the distributor, the induced electric pressures are commutated to the several plugs as are those in Type C.

As the armature is revolved, through its positive driving relationship with the engine crank shaft, two separate and distinct pressures are induced in the two windings. That induced in the light line winding does not flow because its metallic circuit is incomplete, but it is welled or dammed up in the conductor of the incomplete circuit so that it is virtually a potential pressure, in the same sense that a weight placed upon a shelf possesses potential or stored energy. The number of turns in the winding directly connected with the distributor, here called the light line winding, for the purpose of distinguishing it from the other winding, called the heavy line winding, is insufficient for the induction of a great enough pressure to cause the bridging of the plug gap and the unaided production of a spark. However, the current or pressure induced in the second (heavy line) winding is brought to the aid of the pressure in the light line circuit in the following manner:

(*Concluded on page* 67)

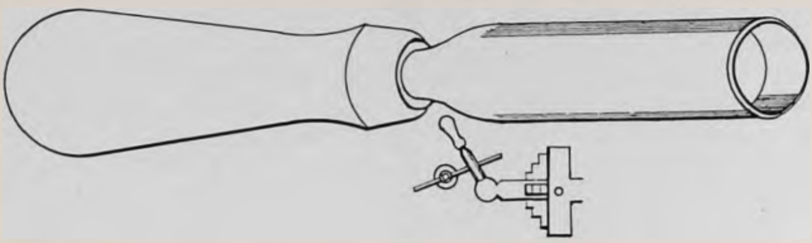
PRACTICAL HINTS

Ball Tool

JOHN A. COOK

There is scarcely a piece of static electric apparatus but has one or more brass balls or spherical-ended conductors somewhere in its makeup.

With the tool illustrated in the accompanying sketch, the amateur can make a ball as round and smooth as anybody can.



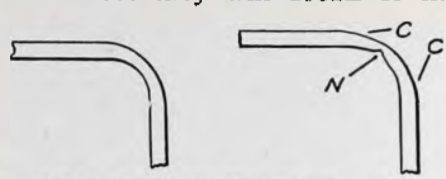
Take a piece of round steel (an old tap shank answers well), square up the end and drill a hole a short way in it. Draw out or grind down the other end for handle. In hardening, dip the whole tool, commencing with the back end, and draw the temper with a hot nut. If dipped with cutting end first it will be almost certain to crack at the bottom of the hole. The ball should be roughed out first with a tool or common scraper and finished with this tool.

A tool with a ½ in. hole in it can be used on balls from about ⅝ to 2 in. in size and other tools and balls in proportion.

Bending Pipe Under Difficulties

It is a difficult matter to bend pipes at any time without proper appliances, especially at sea, and engineers as a rule have no very clear notion as to how to accomplish this work if they are faced with trouble of such a character. A knowledge of a few ways of doing this work is therefore very useful; as, for example, in cases where it becomes necessary to fit up a speaking tube, say, between the deck and the engine room or from the chief's berth to the engine room. A speaking tube of this nature may be made from old condenser tubes, and this becomes quite easy if the engineers know how to bend such tubes to any required shape.

This is done by filling up the tube with sand and blocking up the ends. If no sand is available, resin will do instead. When the pipe is filled it can be bent to any shape, and if it is not too large in diameter it may be bent cold. Iron pipes above 1 in. diameter may be bent without sand if care is taken to have the part to be bent maintained at a good red heat. It is hardly necessary to say that, if the pipe is not filled, it will usually go flat at the bend and have a bad appearance, and in the case of condenser tubes they will break or kink.



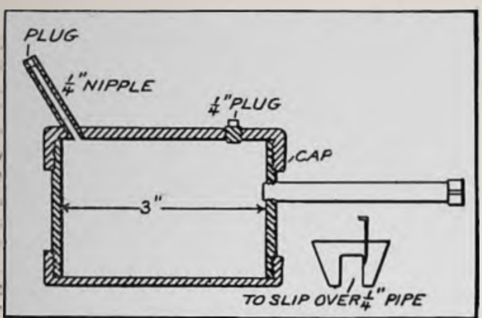
BAD BENDS AND HOW TO TAKE OUT A NICK

The illustrations show the way the piping becomes distorted if it is bent without an internal filling.

In some cases a nasty nick is obtained, as shown in the second illustration. If this should occur in an iron pipe, a method of taking this out again if the pipe is not fractured is as follows: The whole bend *CC* should first be heated to a good, red heat, and this cooled down all over except immediately at the nick N. The part which is left hot will then come out to its original position. The second sketch shows the parts which have to be cooled CC, and left heated N, respectively.—J. H. SMITH in *International Marine Engineering*.

Home-made Gasoline Torch

The sketch shows how a cheap and extremely handy gasoline torch can be made of stray pipe fittings. The generating cup is rolled out of tin with a wire hook riveted in, to lay over the end of the nipple, and hold the cup while heating the fire tip.



HOME-MADE GASOLINE TORCH

It is cheap, heavy and serviceable. The hole in the plugged end of the nipple can be drilled to suit the maker regarding the size of the flame desired. With all joints tight this torch is very safe and needs no compressed air to operate it. A. W. BENTLEY, Jr., in *Practical Engineer*.

A Troublesome Ring Oiler

On the armature shaft of a Manchester type dynamo in an English station trouble was experienced with a ring-oiled bearing having only one ring. As told in *The Engineer-in-Charge*, by O. G. A. Pettersson, a long box with two tubes was provided for oiling each end of the bearing, but this was found inconvenient. Unless the siphon box was used the ends of the bearings were found to get hot, so a trough of sheet metal was placed above the ring oiler, as shown in Fig. 2, so that it caught the oil thrown off the ring by centrifugal force. From this trough the oil was sent towards the ends of the bearings, through holes

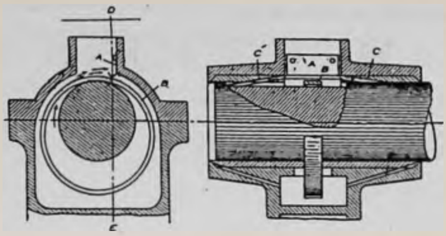


FIG. 2. REMEDY FOR A HEATING BEARING

drilled in the cap and top of brass, as shown in the figure. The direction of flow of the oil was as indicated by the arrows.

How a Magneto Makes Electricity

(*Concluded from page 65*)

The pressure values induced in the two windings increase from zero to a maximum, Fig. 12, and at the instant at which the potential pressure in the light line winding is at a maximum that in the heavy line circuit is also at its maximum. When the point of maximum induction is attained in the rotation of the armature, Fig. 11, the circuit of the heavy line winding, heretofore closed through the circuit breaker, is opened by the engagement of one of the cam rollers with the lever arm carrying the "grounded" contact point; and the pressure heretofore existent in the heavy line circuit is suddenly impressed upon or added to the potential pressure latent in the light line winding. This impressment of one pressure upon the other so increases the value of the resultant pressure that the air gap at the spark plug is bridged and an ignition spark produced. The distributor used with this system is identical with that used with system type "C," and is operated and acts in exactly the same way.

Experiments were conducted recently with geared turbines on the British steamer *Vespasian*, for the purpose of determining whether this means of propelling would be a saving in regard to fuel, weight and space in comparison with the best types of reciprocating engines. The result of the first test, as attained on an ordinary sea voyage, gave a decreased steam consumption of 15 per cent.

QUESTIONS AND ANSWERS

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

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

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

1618 **Horse-Power.** W. F. C., Fall River, Mass., asks: (1) Which of the common motive powers, under equal conditions of diameter of pulley, speed and horse-power, will give the greatest torque? (2) Can any furnace exceed the temperature of that produced by electric means? Ans.—(1) While your question is rather illogical, we can guess what point you have in mind. Under the conditions you have mentioned, it is certain that from the definition of a horse-power, they must all exert exactly the same torque. The difference you have in mind is most likely in regard to their overload capacity. A steam engine, whether of the reciprocating or turbine sort, has an enormous overload capacity. No matter what load is assigned to one of these prime movers, it is able to struggle along at some speed. The horse-power and torque it may exert under these conditions may greatly exceed the normal rating. For an hour's run an engine may be worked at 50 per cent. or even 100 per cent. overload. An electric motor of the direct-current type may similarly assume enormous overloads, and the only evidence of the excess horse-power it may be yielding would be its considerable increase in heating and sparking, or its blowing of fuses or opening of a circuit breaker. An alternating current induction motor, on the other hand, has a considerably lower overload capacity, and if, say, 25 per cent. above normal horse-power be demanded, it may stop. Similarly, the gas and gasoline engines have very small overload capacities. In this last case, the limitation is so recognized by engineers as to require that for securing reliability of service, storage batteries shall be operated in conjunction with them; then, by the proper equipment of auxiliary apparatus, the overloads will automatically be assumed by the batteries. (2) Not entirely so, but with the extra qualifications that the electric furnace has its heat applied internally, instead of externally, and that it is readily controllable, the latter has the greater qualifications for many important works.

1619. **Casting Babbitt Metal.** W. R., Somerville, Mass., has tried to make a casting in a plaster of Paris mold, but meets with continued failure. He asks if we can suggest the reason. Ans.—Your letter did not give the particulars of the methods you have used, so our advice may be useless. You might have used the loose powder, or have formed it when wet. If this latter is the case, you should have thoroughly baked the mold, so as to have expelled all the water. If the mold is wet, the molten metal will liberate such quantities of steam as to fill the casting with blow holes.

1620. **Spring Tires.** P. H., Bentonville, Ark., sends a sketch of a wheel for an automobile that has, in place of the ordinary pneumatic rim, a closely arranged assemblage of steel plates, slanting off like a herring bone, and asks what there is about the scheme that is impractical? Ans.—It is likely that on some sort of pavements the device would support a vehicle, but ordinarily, the device would be subject to many disorders. There would be quite a difference in the action between forward and backward rotation. From some roads, clay or mud might become so packed between the springs as to interfere with their freedom. Small stones wedged in would certainly result in breaking the springs. At high speeds they would appear to have a disastrous action on good pavements. They would be dangerously slippery on oiled roads or when crossing car tracks.

1621. **Hardening.** A. J. A., Milton, N.D., asks several questions as to the method of hardening a plate of Jessop's steel, 16 x 8 x 1 in., that is to be used for a die for punching holes in No. 18 gauge sheet iron. Ans.—If you can possibly avoid the necessity for hardening such a block, by all means avail yourself of the escape. Still, if there is no other way, reverse the procedure you proposed, and make the die first. It can perhaps be safely hardened by immersing it in lead bath, heated to the desired temperature. Then immerse the plate in oil rather than in water. After this has been surface ground, use it as a templet for drillng the holes in the soft steel plate into which the punches are to be set. If you do the work in the other order, the hardened plate is not likely to escape distortion in the hardening process, and then the holes in the two parts would not match. If the holes you propose to punch are not so close together as to forbid, let the lower plate be of soft steel, identically drilled with the upper one. Even cast iron might do. Then enlarge these holes with a good fitting counterbore, and set into each hole an individual die. These are cheap and can be purchased from many manufacturers, and the addresses of a few representative ones we would be glad to furnish, if you desire. If one of these small dies breaks, it is a simple and cheap matter to replace it.

1622. **Underload Switch.** H. H., St. Paul, Minn., asks: (1) What should be the winding of the automatic device of this sort described in the March, 1911, issue, to adapt it to voltages from 30 to 50? (2) Does the coil have an iron core? Ans.—(1) No. 30 single cotton-covered wire should be suitable. (2) Yes, it has the movable iron core, which is sucked in by the action of the current, or withdrawn by the spring.

1623. **Resistance.** H. E. I., Easton, Pa., asks: (1) What would be a good resistance to put in series with his induction coil to allow use on a 110 volt alternating current circuit? Core is 8 in. long, ¾ in. in diameter, wound with two layers of No. 16 wire; secondary is wound in sections ¼ in. thick, and has 3 lbs. of No. 30 enameled wire. (2) What is considered to be the better wireless receiver, the Murdock or the Holtzer-Cabot? Ans.—(1) There is such a variety of resistances, all equally good, as to make a single answer inappropriate. It may be that you have already on hand, or can easily get, proper materials which would answer quite as well as some elaborate arrangement we might suggest. First of all, it must be non-inductive: that is, it must not be made of iron, and preferably, even if of other metal, not wound in coils. Let the wire, if that be used, be strung back and forth on a suitable frame. A pound of No. 18 German silver wire, of the 18 per cent. grade, should amply suffice, but the amount to be inserted in circuit can be determined only by experiment. To this end the resistance should be made adjustable. A bank of incandescent lamps, in parallel with each other, put in series with the coil, makes about the cheapest and most rugged resistance you can make. (2) We cannot discriminate between our various advertisers. Both makes are good. See recent articles by W. C. Getz.

1624. **Piston Rings.** W. R., Eldred, Pa., asks: (1) How to turn piston rings for small steam and gas engines? (2) What is a plain rule for calculating the fields and armature of a generator or motor of any desired capacity? (3) Explain counter electromotive force of a motor. Ans.—(1) Cast iron is the best material, and a piece made in the form of a pipe with a flange at one end is convenient. The cored hole should be such as to leave the metal thicker on one side than the other. First hold the piece in a chuck and turn off the flange smooth, so as next to allow its being held firmly in a chuck or on a face-plate by that end. Bore out the inside to any convenient diameter, then reset so as to turn off the outside, this being rather smoother than the other cuts, and to a diameter slightly larger than the bore of the cylinder. With a cutting-off tool cut off as many rings of the desired length as the stock will afford. Take a diagonal saw, cut through the thinnest part of these rings, and spring them into position. Some practice will, of course, be necessary to find out the proper dimensions. (2) We regret that no simple rules can be given. The design of a dynamo is subject to so many conditions and specifications as to require each type to be worked out separately. A dynamo designer has about the same problems to solve as an architect, and the adjustment of the different parts with the assigned conditions of efficiency and cost often makes the actual solution rather tedious. (3) This was well explained and illustrated in our former "Engineering" series, in the February, 1907, issue. Can you get access to a copy?

1625. **Gasoline Engine.** W. J. H., Barnesville, O., asks: (1) Is not a 4-cycle engine more economical of fuel than one of the 2-cycle sort? (2) If this is so, why are some model electric lighting plants equipped with the latter? Ans.—(1) Yes, it is true. (2) The only reason is that under some circumstances it is about as cheap to withstand the lower economy for the sake of saving largely in first cost. Again, very small 4-cycle engines are not commonly put out by the regular manufacturers. 2 to 3 h.p. represents the beginning of the sizes of the best known 4-cycle engines.

1626. **Winding.** J. L. M., Brockton, Mass., asks: (1) What is the meaning of the dimensions of a bobbin 1¾ in. in diameter, ½ in. thick, ¼ in. channel, and 1 in. bed? (2) How can such a bobbin be wound with No. 30 enameled wire, 24 ft. in length, with 20 strands? (3) How is the winding done so as to have 20 turns per inch of No. 20 wire? Ans.—(1) The phraseology is rather unusual. We wonder where you encountered it. We can only guess that perhaps rather thin sections of a winding were aimed at, and that in this case, the overall width was ½ in., while the flanges were of ⅛ in. stock, which would reduce the winding space to ¼ in. in width. The radial depth for the wire might be 1 in., but this would leave only a small hole in the center. (2) We think "turns," and not strands would be our idea. We have a suspicion that the wording is that of someone who, with a rather overestimated knowledge of English, has translated some article from a foreign paper. (3) Perhaps the wrong number in the wire gauge was given. Certain that with No. 20 single cotton-covered, 28 turns can be placed in an inch. To get in only 20 turns, an unnecessary amount of insulation would be needed, else No. 17 wire could be used. Even if the Birmingham gauge and double-covered wire were intended, there could still be 23 turns per inch.

1627. **Alternating Current Motor.** A. H. McK., Vancouver, B.C., has a machine of the following dimensions and construction: two upright field cores 2¼ in. in diameter, and 3½ in. in length, each wound with 9 layers of No. 20 s.c.c. wire. Armature is of the smooth core drum type, 4 in. long, 3 in. in diameter, wound with 16 coils, 24 turns per coil, of No. 20 wire. There are 8 commutator segments. Iron of both parts is solid. He has tried to operate machine as a motor on the 110 volt alternating current circuit. It will not even generate a direct current when field is separately excited. What is the reason? Ans.—We have been successful in a good many cases in this "absent treatment" method of locating dynamo troubles. Perhaps we can succeed again. First of all, you must be sure that the current flows around the two field spools in the right directions,—that is, in opposite directions. As the current goes from one coil to the other, it should take an S path. The battery test should prove the correctness, for the two poles should attract a compass needle in reversed direction. Perhaps you have these connections wrong, whereby the armature rotates under the influence of two north or two south poles, not under one of each sort. Then again, the armature may not be correctly wound. As you have only half the usual or desirable number of commutator segments, your winding is a little different from that we ordinarily describe. Did you wind one coil, then skip a space and its opposite, and wind the second coil in No. 3 space and its opposite? This would be correct. If you have to rewind the armature, you will find some helpful directions in the article on Armature Winding, in the November, 1908, magazine. Do not try to operate the machine as a motor of any sort on the alternating current. It will not run without disastrous heating and sparking, and at best will have only a little power. See the two articles in our former "Engineering Series" on "Alternating Current Motors," in the October and November, 1907, magazines.

1628. **Fan Motor.** J. P. D., Newark, N.J., has a 110 volt direct-current fan motor which he is using on alternating currents. It revolves in the wrong direction. Exchanging the leads to the brushes results in giving no rotation at all. What is the reason? Ans.—You have given no information as to the structure of the motor, and if it does not have a laminated field structure, you will find its use on alternating currents rather uneconomical. If the windings of the field is in shunt, you have almost no current flowing in that winding, and the torque is due to the field established by the armature current. If the winding is of the series sort, you may find some gain in connecting the two field coils in parallel rather than in series with each other. To exchange the armature connections is the regular and effective method of reversing the direction of a motor, and your failure seems to indicate that perhaps you confused the wires. Please repeat the test, and shift the brushes backward and forward, if the construction permits, then let us know the results.

1629. **Alternating Current Motor.** L. P. C., Berkeley, Cal., sends a sketch of a proposed motor having an ironclad bipolar field magnet with bore 2¼ in. in diameter, and 2$\frac{11}{16}$ in. long; a toothed armature with 12 slots, and a 12-segment commutator is provided. He asks (1) what should be the winding to permit the use of the machine on 220-volt 60-cycle alternating current circuit? (2) Ordinary flux densities of magnetic lines per square inch are given as 60,000 to 90,000 for 25-cycle transformers, 40,000 to 60,000 for 60 cycles, and 30,000 to 50,000 for 125 cycles. Why this variation? (3) If two coils are wound with the same length of wire, say 90 ft., but one of them on a tube 1 in. in diameter, while the other is on a ½ in. tube, will their inductances be equal? How can two coils of different dimensions have the same inductance? Ans.—(1) Your design is a very pretty one for lower voltage direct currents, but is not practicable for alternating. For such circuits the field structure should be laminated. We doubt your ability to insulate safely for 220 volts. For the ordinary construction of alternating current motors we would refer you to the "Engineering" Articles given in the October and November, 1907, magazines. (2) The higher the frequency the greater the eddy current and hysteresis loss. Therefore, for given limits of loss by these inevitable causes, it is only a matter of economy not to work the iron at so high a magnetic density at the high frequencies as at the low. (3) If the size of the wire be small in comparison with the diameter of the spools, the inductances in the two cases would be closely the same. That is, if you wind the whole length in a single layer on a diameter of 1 in., a certain number of turns, 344, will result. A certain area of section will be embraced, *i.e.*, .7854 of a square inch. Now on the same length of a core, but of ½ in. diameter, wind two layers; or, on twice the length wind a single layer. You will get on twice as many turns, or 688. The area enclosed will be only one-quarter as much as in the first case. Self-induction, or inductance, varies directly as the number of lines of force enclosed by a coil, and in your case,—without iron present,—there will be only one-fourth as many lines in the latter as in the former winding. Therefore, on this comparison, the inductance will be only one-fourth as much. Self-induction also varies as the square of the number of turns of the coils. So, having twice as many turns in the one as the other, there will be four times the value from this arrangement,—just offsetting the reduction from the smaller number of lines of force. This proportion must not be carried too far, for when the difference in diameter between inside and outside layers becomes appreciable, and when the insulation between successive turns is considered, and especially if iron is present,—magnetic material that tends to saturation,—the conditions become complicated and difficult of calculation.

1630. **Fire Alarm Repeater.** T. F. H., Albany, N.Y., asks what the use of such a device is, and if there is any difference between one that is automatic and a manual one? Ans.—It is a common arrangement, in ordinary-sized cities, to have any alarm that comes in on one circuit "repeated" into all the others. This notifies the entire fire department. A "repeater" is an electromagnetic device, closely resembling the construction of a telegraphic relay, that opens and closes another or several circuits, and transmits the same signals that a regular operator might send by use of a key. If, while all the circuits were being repeated into, a new alarm was to come in on one of the wires, interference would result, and this can be prevented either manually or automatically. The particular means would be quite outside the limits of these columns to describe, but we would refer you to the extended descriptions contained in Maver's *American Telegraphy*, pages 440–453.

1631. **Oxygen.** H. T. Van P., Lamona, Wash., refers to the article on oxy-acetylene welding, in the April magazine, and asks about the chemistry of the bleaching powder and the barium processes mentioned. Ans.—The action of the copper sulphate and the iron sulphate is purely catalytic, that is, their change, if any, does not enter into the essential operation, *i.e.*, the liberation of the oxygen. The formula for the reaction is, $CaCl_2O_2 = CaCl_2 + O_2$. All that can be said of the other materials and the agitation is that they give favorable conditions. In the barium process, barium monoxide heated in the air to about 70 or 80 degrees C. combines with more oxygen and forms barium dioxide. This form will keep indefinitely, and when pure oxygen is desired, the material is to be heated to about 700 degrees C., when the oxygen will be driven off leaving a residue of the monoxide, as at first.

1632. **Tesla Coil for Wireless.** E. K., Richmond, Va., asks: (1) His receiving radius? (2) Can a wireless message be sent by Tesla coil? (3) Would it be essential to wind the secondary of a ½ in. coil in eight sections? Ans.—(1) We refer you to the February, 1910, issue for answers to these questions. (2) The oscillation transformer used in modern transmitting stations is in reality a Tesla coil. The secondary, however, consists of but few turns of comparatively heavy wire instead of many turns as in the form of Tesla coil used for producing high-frequency sparks. (3) A ½ in. coil may be wound in layers providing a layer of empire cloth is used between each two layers of wire. The layers of wire should not be brought out to the extreme edge of the cloth in this case. The method of winding in sections is to be preferred in the construction of any coil, but where the spark length is ½ in. or less, the layer winding will be found to give very good results.

1633. **Indoor Aerial.** J. McA., New York City, asks: (1) If he could put up an aerial in his garret running wires along the scantlings on good porcelain insulators as per sketch he sends us? (2) If there would be any danger from electrical storms? Ans.—(1) Yes, an aerial of this kind should give fairly good results. We must refrain from making an estimate of your receiving radius, as such an estimate would necessarily be in the form of a guess, on account of the many unknown factors entering into the case. (2) We do not think there would be undue danger from electrical storms, providing your aerial is well grounded when you are through using it.

1634. **Receiver; Interrupter.** J. J. N., Marquette, Mich., asks: (1) If the telephone receiver shown in the drawing he sends us would be of any use for wireless work for distances of a mile or so? (2) How he can stop the buzzing caused by the a.c. illumination feed wires which are a few feet from one end of his aerial? (3) Which is the best position for the vibrator of his 1 in. coil, near to or far away from the end of the core? Ans.—(1) You might be able to use the receiver shown for short distances; however, we doubt if the results will be very satisfactory. (2) The buzzing sound may be considerably reduced by placing the aerial wires at right angles to those of the a.c. feed wires. (3) It is desirable to have the vibrator as close to the end of the core as possible and still allow sufficient room for the vibration. For a very rapid interrupter 1/16 in. or even less is sufficient space.

1635. **Ignition Coil.** F. J. S., Haverhill, Mass., asks for specifications for a jump-spark coil for a two-cylinder gasoline engine. Ans.—Core ⅝ x 6 in.; primary two layers of No. 18 d.c.c. wire; four layers of empire cloth over primary; secondary 1 lb. of No. 34 s.s.c. wire wound in four sections; condenser 100 sheets tin-foil 2 x 4 in. The interrupter should be a very rapid one and we should advise you to purchase one similar to that used on the Heinze coil. It is essential that the spring be very short and the armature as light as possible. Two complete coils should be made according to these specifications and arranged side by side in a suitable wooden case, after which the case may be filled with melted paraffin wax. The interrupters may be conveniently arranged on the top of the case where they are readily accessible.

1636. **Brass Rods, etc.** C. O. W., White Plains, Ky., asks where he can obtain brass rods, ferrotype plate, and tin-foil? Ans.—We refer you to our advertising columns, where you will find the announcements of advertizers who carry such supplies for experimenters.

1637. **Formula for Silvering.** J. L., Louisville, Ky., asks for formula for silvering brass, bronze, copper, etc. Ans.—We have on hand such a formula which is said to be very good. This mixture is composed of 10 parts of silver nitrate dissolved in 50 parts of distilled water, and 25 parts potassium cyanide dissolved in distilled water. Mix, stir and filter. Moisten 100 parts of whiting and 400 parts of powdered tartar with enough of the above solution to make a paste-like mass, which is applied by means of a brush on the well-cleaned objects. After this coating is dried, rinse it off, and dry in sawdust.

1638. **Remagnetizing a Magnet.** H. I. B., Bluffton, Ind., asks: (1) How to remagnetize a magnet in a 75 ohm watch-case receiver? (2) For specifications for a ½ in coil using a core ⅝ in. x 5 in.? (3) If an induction motor can be constructed to operate on batteries? Ans.—(1) You may remagnetize the magnet in your receiver by connecting the terminals to a battery of several dry cells connected in series. After you make connection, test the magnet and see if it offers a strong attraction for the diaphragm. If such is not the case the current from the battery is opposing the magnetism left in the steel and the connections to battery should be reversed. It is only necessary to leave the current on for a few minutes. (2) See answer to F. J. S., Haverhill, Mass., in this issue. By using 1 lb. of enameled wire instead of the silk-covered wire you may get it in a sufficiently small space to permit the use of the 5 in. core. (3) No, an induction motor requires an alternating current for its operation.

TRADE NOTES

We take pleasure in acknowledging receipt of an attractive booklet under the title of "Electrically Heated Appliances," from the Manhattan Electrical Supply Co., New York City. The booklet calls attention to the most excellent line of electric toasters, stoves, chafing dishes, percolators, cookers, glue pots, wax pots, soldering irons, household irons, etc. The economy and convenience of electrically heated appliances is so well known at the present day that very little need be said on this score. The Mesco Apparatus, however, combines many unique features and mechanical advantages with those above mentioned.

The electric toaster is equipped with adjustable doors, on which the bread is placed and which may be placed close to the heat unit for making toast quickly and crisp, or they may be withdrawn to the proper distance for making a hard, brown toast. If the doors are pulled out the full distance the toast remains heated and will not burn. The finish of the instrument is highly polished nickel-plated brass, and it has a solid porcelain base. The current consumption is 450 watts at greatest heat.

The booklet calls attention to the disc stove having a diameter of 4½ in., and which may be used to warm plates, boil water or milk, or for any other purpose requiring the use of heat at or near a table or in a sick room. This, combined with the fact that there is no odor, dirt, or unnecessary heat, makes the stoves convenient to anyone having electricity in their home or office. The disc heater is manufactured in several styles and sizes to meet various requirements. The maximum current consumption of the various sizes range from 250 to 600 watts.

The Mesco soldering iron consumes but 175 watts, and all of its parts are interchangeable and may be renewed at a nominal cost. The 175 watt iron is equal to a 3 lb. soldering copper. All of these appliances are made for the use on either 110 or 220 volt alternating or direct current circuits.

This Company has also recently issued a folder covering ignition apparatus and accessories for automobiles and motor boats. They will be pleased to forward their literature to readers who are interested.

BOOK REVIEWS

Electroplating. A treatise for the beginner and for the most experienced electroplater. By Henry C. Reetz. Chicago, Popular Mechanics Company, 1911. Price, 25 cents.

This little handbook is apparently written by a man who has had much shop experience in plating, and his directions for the various branches of this art are extremely practical and written from the standpoint of the man who must make a living by his work, rather than that of the amateur. His methods savor much of rule of thumb, and the directions for current strength and the making of solutions are not as explicit in all cases as might be desired. In the chapter on silver-plating we note a fundamental error of the most serious nature, which would render impossible the successful performance of the operations. The writer says more than once, that the silver solution is to be made by dissolving chloride of silver in distilled water, and then adding potassium cyanide to precipitate the silver from the solution. As every tyro in chemistry knows, silver chloride is one of the most insoluble salts of silver and is used as the means of precipitating silver in quantitative determinations. The plater who should purchase chloride of silver and attempt to dissolve it would find himself in serious difficulties. Of course, the writer meant silver nitrate, but such a simple error as this should certainly not have escaped the attention of the editor of *Popular Mechanics*, who assures us in the preface that the book has been revised by him.

The Seven Follies of Science. To which is added a small budget of interesting paradoxes, illusions, marvels and popular fallacies. A popular book of the most famous scientific impossibilities, and the attempts which have been made to solve them. With numerous illustrations. By John Phin. Second edition, greatly enlarged. New York, D. VanNostrand Co., 1911. Price, $1.25 net.

The author of this book gives in an interesting and readable form an account of some of the various "will-o'-the-wisps" which scientific cranks have pursued in all ages and whose attempted solution is even now engaging the attention of many crack-brain theorists. It is astonishing how such delusions as the possibility of perpetual motion, etc., will persist. No amount of writing will explode these ideas, but every book on the subject must be more or less helpful. In addition to the chapters on these various delusions, he has added a large number of paradoxes, illusions and marvels, a number of curious arithmetical problems, and explanations of a large number of popular fallacies and common errors, making a readable book.

CORRESPONDENCE

2321 Perrysville Ave., N.S. Pittsburg, Pa.
April 10th, 1911.

Sampson Publishing Co.,
Boston, Mass.

Gentlemen: On Friday, March 24th, "The Wireless Association of Allegheny County" has been organized for the furtherance of knowledge in the science of wireless telegraphy and telephony among amateurs. The officers elected at the meeting are as follows: president, George B. Richards, Jr.; vice-president, Lawrence Montgomery; secretary, Burton P. Williams, 2321 Perrysville Ave., N.S. Pittsburg, Pa.; treasurer, Arthur O. Davis.

Any person wishing to become a member must be the owner and operator of a wireless station and must be within the limits of Allegheny County. There are as yet no dues or admission fees to be paid. Any person wishing to join must communicate with the Secretary. There are twelve members enrolled.

Yours truly,
The Wireless Association of Allegheny County
Burton P. Williams, Sec'y.

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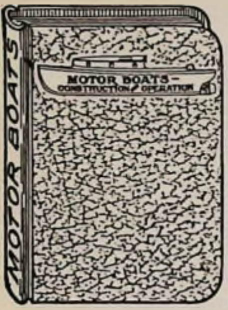

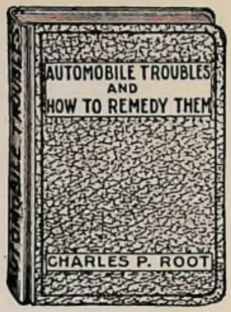

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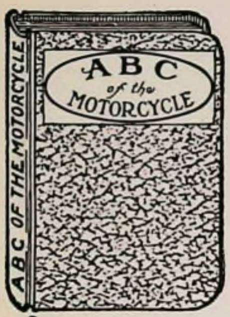

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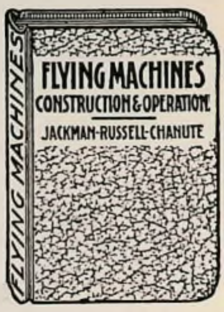

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