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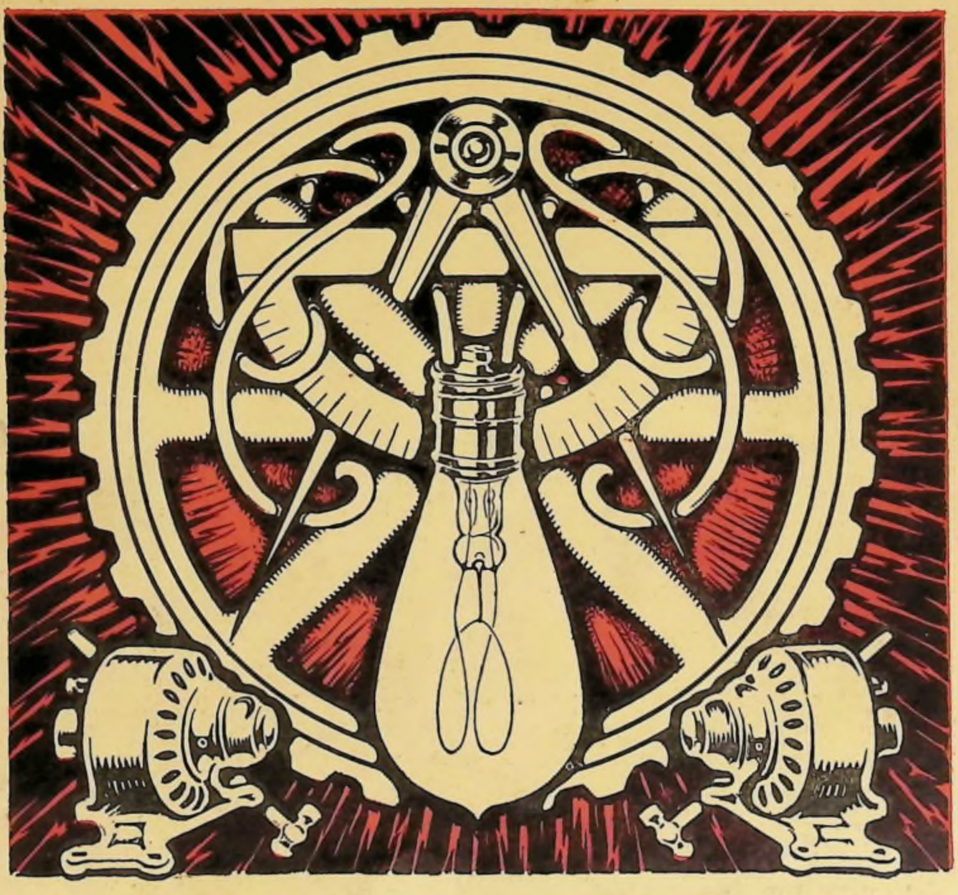

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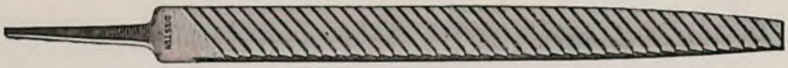

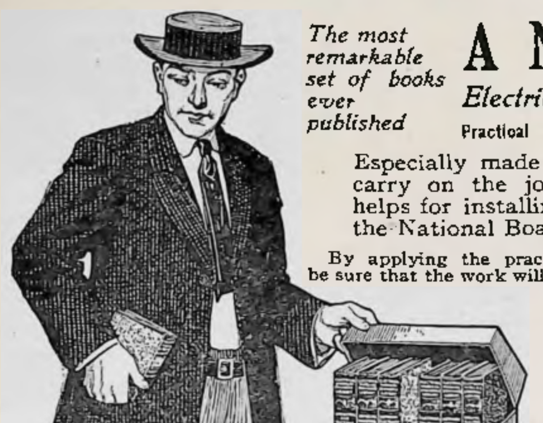

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ELECTRICIAN & MECHANIC

VOLUME XXIII SEPTEMBER, 1911 NUMBER 3

UNDERGROUND CONDUIT CONSTRUCTION

GEO. M. PETERSEN

Because of the public feeling which is beginning to show itself as being against the heavy and unsightly "open wire" and aerial cable pole-line construction, as maintained on some of the finest residential streets in our large American cities; because of city ordinances which are being passed to prohibit the building of pole lines in any but isolated districts, and because of the fact that there is less trouble in underground than aerial cable, and it is therefore less expensive as to maintenance, the old "open wire" leads are being abandoned by the telephone, telegraph, light and power companies and the wires being placed underground in cables. This necessitates the construction of underground conduits, or ducts, through which the cable can be pulled. As 600 pair cables are by no means a curiosity it stands to reason that these ducts must be laid with great care and accuracy.

There are three kinds of ducts in general use today, viz., vitrified clay, fiber duct and creosoted wood. The former is unquestionably the best, as it is practically a cheap quality of glass, and, therefore, an excellent insulator. This vitrified clay tile, which we will designate as m.d.t. (multiple duct tile), can be obtained only in one, two, three, four, six and nine duct units. As very often the conduit, or subway, consists of from twelve to sixty ducts, the units are combined as shown in Fig. 1, which also gives an idea as to the combinations that can be obtained. The cost of m.d.t. is only about 4½ cents per duct foot, delivered on the job, so that it is the cheapest as well as the best of materials. There is more or less breakage in handling, however, and the actual cost will probably run between 5 and 5½ cents per duct foot, in the average job.

The m.d.t. comes in standard lengths of 3 ft., but the following lengths may be obtained,—6 in., 9 in., 12 in., 18 in., 24 in. and 30 in. These are termed "shorts," and are used principally for the purpose of bringing the main conduit into the manholes.

Fiber Duct, while still used to some extent, does not, on account of the large quantity of vegetable matter in its composition, make as good an insulator as the vitrified clay. The fiber duct also gets soft in the warm weather, and great care is necessary to prevent the duct from becoming flattened during the operation of placing the concrete. By glancing at Fig. 2, which shows a cross-section view of a fiber duct subway, we can readily see that the expense of laying, for material alone, is a great deal in excess of that required for the m.d.t., because of the large amount of concrete which is necessary to do the job right.

Creosoted Wood Duct, on the other hand, is very cheaply laid; no concrete is necessary, no joint covering is required and the sections are lined up by driving them together. Its great disadvantage, however, lies in the fact that when cable is being pulled into one of these ducts, the wood fibers have a tendency to "pile up" ahead of it, and thus make the pulling difficult or impossible; also, after a cable has laid in a c.w.d. for some time, the dirt, rotten fibers, and dust will combine and jam the cable so that it is sometimes impossible to pull it out in case of trouble. While wood ducts are often used for subsidiaries it is very seldom indeed that they are used on a main conduit run.

A Subsidiary is a one or two duct run from a manhole to a service box, pole, building, etc. Any run of ducts which are apart from the main subway and yet attached to it is, generally speaking, a subsidiary. Fig. 3 shows the layout of a section of subway with subsidiaries, service boxes, etc. The right angle bends shown in Fig. 3 are formed of 3 in. wrought iron pipe which is bent before being delivered on the job, and to which the c.w.d. is joined at both ends. In building subsidiaries, a piece of No. 12 gauge galvanized iron wire is pulled through each length of duct as it is added to that in the trench. The wire is then made fast at both ends and left until the cable is to be pulled in. See Fig. 4.

Knowing the advantages and disadvantages in each of the materials which can be used on underground conduit construction, we shall take up in detail the construction of the m.d.t. In building a tile subway, the depth of the tile varies according to its location, and the condition of the soil, amount of traffic, etc. As the largest percentage of this kind of work is built in the pavement we will take this kind of a job as an example, and figure to have the top of the concrete cap, about 3 ft. below the surface of the pavement. Using Fig. 3 as a print of our job in hand, we figure our depth as follows:

Thickness of concrete base.....	4 in.
Height of 9 m.d.t............	1 ft. 1 in.
Thickness of concrete cap......	3 in.
Depth from surface of pavement to top of cap..........	3 ft.
Depth to bottom of trench...	4 ft. 8 in.

As the width of the 9 m.d.t. is 13 in., and the depth of the trench is 4 ft. 8 in., the excavation should be 16 or 18 in. wide. This width will admit of laborers, working on the excavation, to handle the work with ease.

After making the excavation and bringing it carefully to grade, a 3 in. concrete bottom, of the following proportions, is placed in the trench:

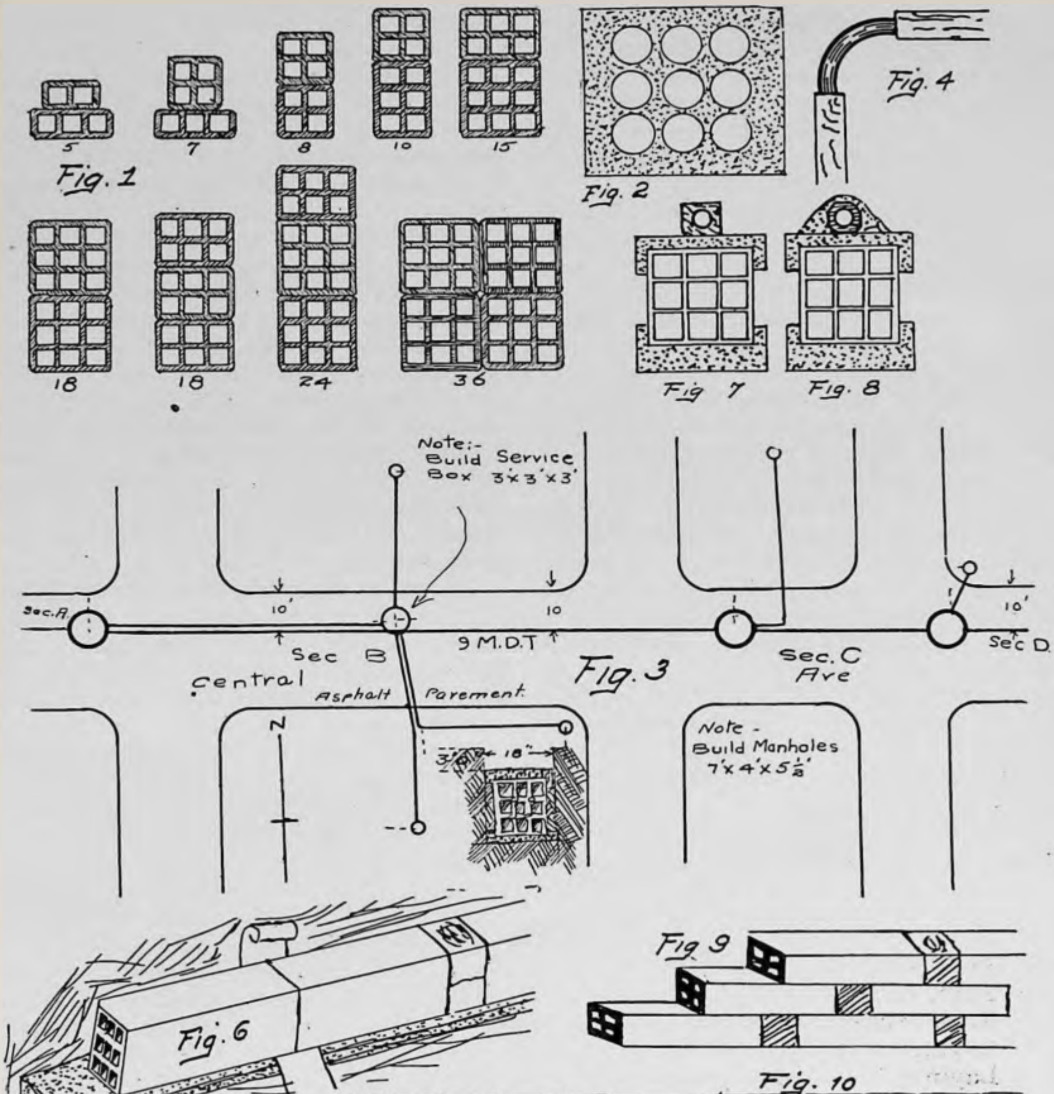
Portland cement..............	1 part
Coarse sand.................	2½ parts
Broken stone.................	5 parts
or	
Portland cement..............	1 part
Gravel.......................	7½ parts

The m.d.t. is now laid upon this foundation, the tile being lined up by placing "dowel pins" in the two top holes of each piece. A piece of single ply tar paper, about 8 in. wide, and long enough to lap on the sides of the tile, is placed over the joints to exclude dirt, concrete and other foreign matter from entering the ducts. This tar paper is fastened by a dab of mortar, placed on top of the tile, as shown in Fig. 6. After the tile is laid, the earth is replaced along the sides of the tile and well rammed to within about 3 in. of the top. Concrete is then poured in until the tile has a cap about 3 in. in thickness. This cap is placed to protect the tile, and cable contained within it, from damage when foreign excavations are being made in its vicinity. Creosoted plank is sometimes used for a cap instead of the concrete. This plank is 2 in. thick and projects over either side of the tile for 1½ in.

Figs. 6 and 7 illustrate the latest practice in subway construction, in having the c.w.d., or single duct tile, on top of the concrete cap. The c.w.d. is preferable, and is ordinarily used. This extra duct is to allow for laterals, or subsidiaries, which may be required from time to time in the future. Without this extra duct it would be necessary to excavate from the poles to the conduit and then follow along the top of the main conduit into the manhole. When this construction is used, however, the laterals are run only from the pole to the main conduit and then tapped into the spare duct which was placed when the subway was first built. This naturally saves the expense of excavating and repaving the long run over the main conduit.

When building subway where more than one unit tile is used, as in Fig. 1, the joints of the tile should be "staggered" or "broken," as in Fig. 9, and a layer of mortar about ½ in. thick should be laid between the units so that the upper tiers may have a perfectly firm and true bed.

Upon the completion of the subway, and before the excavation has been



repaved, a 3 in. square wood mandrel about 1 ft. long should be pulled through each duct. A sole leather collar should be provided at each end of the mandrel, and these collars should fit the ducts very snugly, being renewed as often as necessary to keep them tight. The object of this mandrel is to clear out the ducts of whatever dirt, concrete, etc., may have gotten in during the construction; and sometimes it is necessary to dig up the conduit in order to reach a place where the mandrel has become jammed. For this reason it is advisable to keep plugs in the end ducts at all times except when the tile is actually being laid.

The manholes which are being adopted as standard by the large corporations using this method of construction are built of hard, common brick, using 8 in. walls, except in special cases, where 12 or even 16 in. walls may be necessary, such as on a hillside where the pressure of the earth against the wall makes a thick wall essential to safety. The 8 in. wall requires about 1,500 brick, for a standard sized manhole which is 7 ft. long, 4 ft. wide, with 6 ft. of clear headroom, although the manholes may be varied in size to correspond with the number of ducts which are to enter and consequently the number of cables which must be accommodated. The floors of these manholes are built of concrete 8 in. deep. The roof is an "iron plate" which completely covers the hole when set on top of the four walls. The entrance hole is cast in one piece with the plate, and the weight of this "frame," as it is termed, is close on to 2,000 lbs. This "iron-plate" arrangement does away with the necessity of building a roof with iron rails and brick upon which to set the old style circular frames, which were formerly used almost entirely, and of which there are still thousands in use. Fig. 10 illustrates a manhole with tile running each way from it.

Referring again to Fig. 3 we will see a service box, in sec. B, from which three subsidiaries, or laterals, run. In order to divide up the length of these laterals the service box was placed. This also allows of economy on the cable as one large cable can be run from the manhole to the service box; the three smaller cables can be run from the poles to the service box, and there spliced on to the larger cable which is in turn spliced to the "feeder cable" in the main subway.

In contracting this kind of work plans of the job and specifications for doing the work are sent to the contractor. He in turn fills in the prices on the various "units" of work to be done, and returns same.

The following list shows the principal items upon which bids are received, while the prices which are inserted show the range in price for the various kinds of work:

		From	To
Earth excavation	cu. yd.	$0.60	$1.25
12 in. rock excavation	lin. ft.	.50	.90
24 in. rock excavation	lin. ft.	.75	1.75
Rock excavation in manholes	cu. yd.	2.50	5.00
Laying 2 m.d.t.	lin. ft.	.15	.25
Laying 3 m.d.t.	lin. ft.	.15	.25
Laying 4 m.d.t.	lin. ft.	.12	.40
Laying 6 m.d.t.	lin. ft.	.14	.40
Laying 8 m.d.t.	lin. ft.	.15	.45
Laying 9 m.d.t.	lin. ft.	.17	.50
Laying 10 m.d.t.	lin. ft.	.29	.55
Laying 12 m.d.t.	lin. ft.	.30	.60
Laying 15 m.d.t.	lin. ft.	.30	.60
Laying 18 m.d.t.	lin. ft.	.30	.65
Laying c.w.d.	lin. ft.	.30	.70
Placing 3 in. pipe bends	each	.50	1.00
Sod, removing and replacing	sq. yd.	.07	.25
Concrete walk	sq. ft.	.12	.18
Pavements:			
Asphalt pavement, guaranteed	sq. yd.		3.50
Asphalt pavement, not guaranteed	sq. yd.	1.85	3.25
Meding block, concrete base	sq. yd.	2.40	4.00
Macadam	sq. yd.	.70	1.25
Macadam with Telford base	sq. yd.	.85	1.50

		From	To
Brick with concrete base	sq. yd.	2.25	3.00
Ordinary stone	sq. yd.	.60	1.00
Manholes, brick work, setting frame, racks, etc., 7 x 4 x 5½ ft.	each	40.00	65.00

A great deal could be written on this subject, but, as it is the object of this article to cover the ground as thoroughly as possible in a small space, the principal features and reasons for doing the work only are given.

REASONS AND ACTIONS OF A STARTING BOX FOR A DIRECT CURRENT MOTOR

A. SPRUNG, E.E.
Associate Member A.I.E.E.

From the definition of an electric motor, it is clearly understood that electrical energy must be supplied in some manner in order to produce mechanical power. In what manner can electricity be supplied to the motor?

When a motor is at rest the CR drop is the only reaction in the motor armature. Now, since the resistance of the motor armature is very low, to keep the armature energy losses low, any voltage impressed upon the motor would produce a heavy inrush of current. This consequently would cause circuit breakers or fuses to blow, or if these were not used, the armature winding would burn out.

To limit the amount of electricity supplied a starting box is used. As soon as the motor is started, a reaction takes place in the armature itself. This reaction is a counter electro motor force caused by the inductors on the armature cutting the flux produced by the poles. The counter e.m.f. acts in an opposite direction to the impressed e.m.f., thereby limiting the flow of current.

From Ohm's law

$$\text{Current in armature} = \frac{\text{Impressed e.m.f.}}{\text{armature resistance}};$$

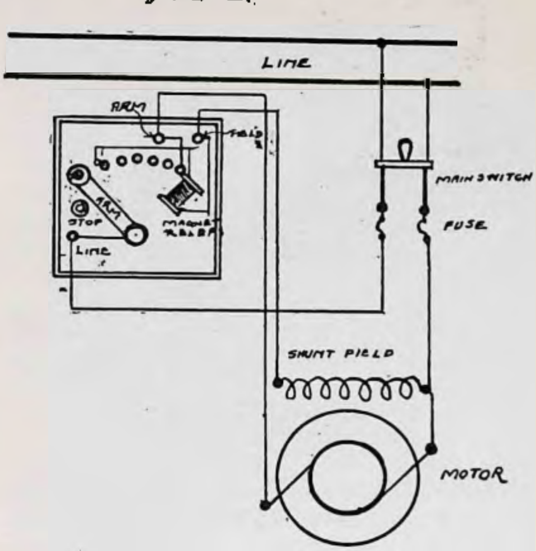
consequently to diminish the starting current in the armature we must increase the armature resistance; then Ohm's law would be

$$\text{Ca} = \frac{\text{e.m.f. impressed—counter e.m.f.}}{\text{armature R+starting box R.}}$$

To control the current we must control the starting resistance to such an extent that for an increasing speed the counter e.m.f. would increase sufficiently to allow starting resistance to be cut out. It is understood that the counter e.m.f. increases with the speed of rotation in a similar manner as the e.m.f. in a dynamo.

After the starting resistance is entirely cut out full line voltage is impressed across the motor which then runs at a normal speed.

FIG 1.

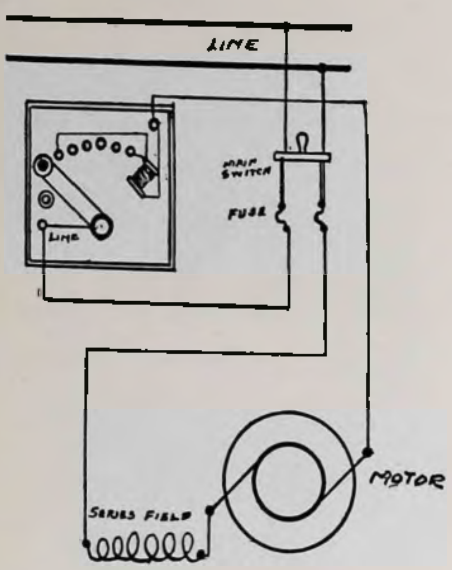


ACTIONS OF STARTING BOX

The methods of operating various starters depend entirely upon their characteristic features. An important feature shown in Fig. 1 is the electromagnet, at the end of the row of contacts, which holds the starting arm in running position as long as the coil is energized from the line. If through any cause the main circuit be opened, the starting arm is released and returns to its original position through the action of a spring attached to the arm. Fig. 1 also shows how to connect up the starter to a shunt motor.

By this diagram the method for starting the motor can be explained. Close the main knife switch. This action should not allow any current to pass through the motor. In case of arcing on the first contact when starting, begin by moving the arm on the first contact holding it there and then closing the main-line switch. Hold the lever arm on the first contact for a second, then move the arm to the second contact for a second and so on from one contact to the other, holding it one second at each contact, until the lever arm has moved over all the contacts to the short-circuit position where it is held firmly by the electromagnet.

FIG 2.



If the motor does not start when the arm is on the third contact, open the main knife switch and look for the following faults: wrong connections, too much load on the motor, an open circuit somewhere, or a short circuit of some kind. To stop the motor, open the main knife switch and let the starting rheostat take care of itself. The lever will not fly back immediately, but will hold until the motor has slowed down considerably. The size of starter to be used in connection with any motor depends upon the current necessary to start the particular motor at the maximum load which the motor will be called upon to drive. The starter should be of sufficient capacity to handle current equal to the normal rating of the motor, except where larger currents are used when starting.

If, at any time, smoke should be seen coming from a rheostat, there should be no cause for alarm, since the smoke is caused by the heating of matter gathered together on the rheostat. Overloaded rheostats are always indicated by discoloration of the resistance and not always by smoke as explained above.

Too much time should not be used in starting up, as the resistance is liable to burn out, if the rheostat has not sufficient capacity. If the motor does not start when the arm is on the first contact, move the arm to the second and third contact to prevent over-heating of the resistance. The arm should never be moved in the opposite direction, as it is liable to cause damage. Always pull the main knife switch to open the circuit.

In starting up a motor for the very first time, little load as possible should be used. The load capacity of the machine should be tested by an ammeter placed in the armature circuit. Connections for starting series motors are shown in Fig. 2.

Drills for Taps

To the engineer who does his own repair work, the accompanying table is a convenience well worth preserving, says B. A. Held, in the *Practical Engineer*. It gives the size drill to be used in making a hole to be tapped for a bolt of given size.

TABLE OF DRILLS FOR TAPS

FOR BOLTS				FOR PIPES	
Size of Tap in Inches	Size of Drill to use Inches	Size of Tap in Inches	Size of Drill to use Inches	Size of Tap in Inches	Size of Drill to use Inches
1/4	3/16	7/8	23/32	1/4	15/32
5/16	1/4	15/16	3/4	3/8	19/32
3/8	9/16	1	27/32	1/2	3/4
7/16	11/32	1 1/8	15/16	3/4	1
1/2	13/32	1 1/4	1 1/16	1	1 1/4
9/16	7/16	1 3/8	1 5/32	1 1/4	1 17/32
5/8	1/2	1 1/2	1 9/32	1 1/2	1 13/16
11/16	9/16	1 5/8	1 3/8	2	2 1/4
3/4	5/8	1 3/4	1 1/2	2 1/2	2 3/4
13/16	21/32	2	1 23/32		

For preserving tables of this kind about the plant, I paste them on a light board of convenient size, then give the entire face a coat of white shellac; this renders it washable and protects it from wear.

SOLDERING AND BRAZING—Part IV.

H. W. H. STILLWELL

TO BRAZE OR SOLDER SILVER ARTICLES

When treating silver in this way, the metal should be bright and clean, and the parts to be united must be as nearly as possible in contact. If there is a gap in the article, lay in it a small piece of wire to form a connection. Borax should be applied to the parts and to the solder also. Care must be used in heating, which must be very gently at first, until the borax boils up and subsides again, then blow steadily with the blowpipe until the solder runs. If the articles to be united consist of a small and a large piece, such as a catch to be soldered to a brooch, first, direct the flame so as to bring the brooch to the running heat of the solder at the point required, then shift the flame so as to heat the catch. Great care must be taken to keep the joint covered by the flame steadily from start to finish, a pause in the blowing, allowing air access to the parts, will often prevent the solder from running.

BRAZING WIRE AND GOLD-FILLED ARTICLES

There are several grades of the so-called gold-filled jewelry. The term "gold-filled," as used by jewelers, includes a wide variety of cheap jewelry. Some of the first articles of this class were made of a thin shell of gold, filled with a fusible metal resembling soft solder to give solidity and weight to the articles. The second class of filled gold articles have thin metal shells filled with a waxy composition. These shells may be made of gold, sometimes of 9 karat quality, or they may be made from a kind of brass named gilding metal, electro gilt, to make it appear like gold. Another class of goods are on the market under the same name and also under the names of rolled gold and gold cased articles. The base of these is really a variety of gilding metal, an alloy resembling gun metal. This may be had in several grades of fineness, cased with gold, and the prices range accordingly. Very well made and desirable articles of this class can be purchased on the market, which will give excellent wear, in the form of bracelets, chains, brooches, pins and rings. The lowest-priced articles are made from the lowest-priced materials, but wears yellow throughout, although losing its gold appearance in time, depending upon the quality. The original gold appearance can be restored by electro gilding. Initial rings are made of these gold cased wires by twisting the two free ends tightly around the ring with a pair of pliers. Other rings are made in the same way as those of brass or the usual gold alloys. The joints may be butted, that is, end to end, or spliced; which will be the easiest for the amateur jeweler. It must be carefully filed to fit very close, so as not to show the joint when completed. These joints may be soldered with an easy-running gold solder, if the workman understands using hard solders. However, as the joints have to be made red hot before the solders run, and as the surface of gold-cased wire is made rough by heating to a high temperature, great care must be exercised in hard soldering. A fine easy-running jeweler's solder should be used, the flux being killed spirit or resin only, and the source of heat a fine blowpipe or a jeweler's self-blowing lamp. These joints can be easily cleaned in hot water. If a harder solder is to be used and borax is employed as a flux, this should be finely ground with water, on a slate or like surface, to a paste, and the solder to fine filings and mixed with the borax paste. As borax forms a sort of glass when heated and the metal is more or less stained or discolored, it is well to boil the article in a solution of washing soda which will both clean the metal and loosen the borax glass. Butted and spliced joints may be secured by sweating them together with soft solder, and if this is carefully done, the solder can be scarcely seen when the joint is cleaned. When the joint has been filed to shape and closely fitted, the ring is opened a little by twisting the ends aside; these are then tinned by touching them with a drop of killed spirit and rubbing them over a hot soldering bolt well charged with solder. A thin film of solder is then placed on the two surfaces of the joint which are closely fitted again, anointed with a mere touch of sweet oil and swept with the flame of the blowpipe. When the wire is overheated and much discolored, it may be restored by electro gilding, which is accomplished in the usual manner with a small quantity of gilding solution heated in an enameled iron sauce pan or in a clean pipkin and worked with an electric current obtained from a dry battery or other source of electrical energy.

TO CLEAN SILVER CHAINS

When silver chains are discolored or tarnished, they may be restored by rubbing them with rouge powder which has been well rubbed up in best sweet oil. Boil the article in clean hot water to remove the rouge and oil, then polish with dry rouge, finishing with ground whiting. This process may be used to good advantage upon small articles and will give excellent results and act quickly.

TESTING GOLD FILLED AND ROLLED GOLD

The so-called "gold filled," "rolled gold" and "gold cased" jewelry all mean about one and the same thing. The material is supposed to consist of a plate of gold brazed to a plate of brass or other metal, which may be some alloy, or the basic metal itself, and the resulting double plate rolled out thin. Articles such as jewelry or watch cases made of this material usually consist of brass with a very thin surface of hard gold, the quality of this outer coating and the thickness varies with the class of work, some cases have an 18 karat rolled gold and are guaranteed to stand acid outside and wear for twenty years. In the cheaper work, 9 or 10 karat gold is often used, and the coating is almost as thin as that produced by electro gilding. The cheap electro-plated or gilded jewelry is often fraudulently represented as gold filled, rolled gold, etc. The best test for this class of articles is to file a small but deep nick in the metal and apply a drop of strong nitric acid to the exposed section. The brass portion will turn green while the outer coating will remain unaffected, and its thickness and quality be determined. A jeweler's powerful eyeglass or any good magnifying lens will aid in the test. If such articles as these are to be soldered, great care must be observed in the operation, and the least amount of solder used that will produce a good strong joint. Gold solder may be used to good advantage and the resulting joint will not tarnish if made properly and thoroughly cleaned, after being soldered or brazed. Other solders or brazing alloys may be employed, but the joint will tarnish or discolor unless regilded.

ANOTHER METHOD OF TESTING GOLD

It is by comparing the way in which nitric acid acts on certain known quantities of gold with the way it acts on the articles to be tested, that the quality of the latter is ascertained. The usual outfit for making such tests consists of few and simple materials although more or less expensive (*a*) a piece of touchstone (usually a piece of Lydian stone, which is a black variety of jasper); this has its surface smooth and partly polished, but is not bright. A piece of Wedgwood black ware will also answer the purpose although the jasper is much the best. (*b*) a series of "needles," so-called, or pieces of gold strip or wire to be used as standards of comparison; of 9, 10, 12, 14, 16 and 18 karat quality. (*c*) Nitric acid should be kept on hand in a special bottle having a long pointed stopper by the aid of which a drop of the acid may be removed from the bottle and applied wherever desired, and not come in contact with the fingers, for it destroys and discolors skin wherever it touches. These for gold, while having little to do with soldering or brazing, may be of service to anyone who may be in doubt as to the quality of some article; to such, a reliable test would be most acceptable.

SILVER SOLDERING

The soldering of silver is much employed in the arts, and owing to the small quantities of the solder required or the careful way in which it is used most work requires little finishing after being soldered. This solder, although expensive, is in reality the cheapest solder in the long run. The silver solder is rolled down to the desired thickness and cut into narrow strips with the shears. The joints or edges to be united are coated with pulverized borax which has been heated to drive off the water or crystallization. The small strips of solder are then placed with the forceps upon the edges or joints to be united, and the work is heated upon the brazing hearth. To hard solder small work, using silver or gold solder, such as drawing instruments, jewelry, buttons, etc., the blowpipe is almost exclusively used, and the solder is of the finest or best quality such as gold or silver solder, which is usually rolled in thin sheets or very fine wire, and it is sometimes pulverized or granulated by filing. In soldering jewelry the worker usually applies the borax or other flux in solution with a small camel's-hair brush. The amount of solder required for the work must be determined and that amount used so that when the work is all finished, there will be no excess to be removed by filing or scraping. The borax or other flux is removed by rubbing the work with a rag which has been moistened with water or diluted acid. The usual flux used for this class of work is borax, many others are on the market, but as good results can be obtained with it as with any of the others.

GOOD SILVER SOLDER

An excellent silver solder can be made as follows: Melt together 5 dwt. fine silver, 1 dwt. 8 gr. fine copper and 8 gr. spelter; or else to the 5 dwt. of silver 1 dwt. 16 gr. brass wire of good quality. These and some other alloys contain a volatile metal-zinc, and must have the silver melted before the brass is added; borax should be freely used all through the operation. A softer solder than the above can be made by using 10 dwt. fine silver and 5 dwt. brass wire, melt and roll or flatten to size 6 or 7 cut into strips or any desired shape, or it may be granulated or filed and mixed with the flux. If a still softer solder is desired, use spelter in place of the brass wire. All these solders can be purchased from any good supply house handling soldering and brazing materials.

AN EXCELLENT SOLDER FOR GOLD WORK

In soldering articles of gold, the solder used is usually made from gold of the quality of the article 14, 16 or 18 karats, to which is added a very small amount of silver and copper, or a larger proportion of silver and copper for work of inferior quality. The quality of the solder is always a trifle inferior to the metal on which it is used, so that the solder may melt at a lower heat than the article on which it is used. Gold of 18 karat quality will melt at 1,995 degrees Fahrenheit, 15 karat is 1,992 degrees and 9 karat at 1,979 degrees; soft or easy silver solder at 1,802 degrees Fahrenheit. This shows that, although 9 or 15 karat gold could be used to solder 18 karat, it is not possible to use 18 karat to solder 15 karat. The same principle applies to silver and brass; and the quality of the solder has to be known before any attempt should be made to do the soldering of the article. Another point which must be kept in mind—thin gold articles, like brooches, will not stand so hard a solder as the same quality of gold will do when made up solid, as in the case of a badge, pin or bangle ring. Solder for 18 and 16 karat is made by using 1 dwt. of gold and add 2 gr. fine silver and 1 gr. fine copper; melt well together and roll out thin. For 12 karat quality the addition of 3 gr. fine silver and 1 gr. of fine copper to the dwt. will give best results; if the gold is of an inferior grade, as, 9 or 10 karat, the best solder is made from 1 part fine gold, 1 part fine copper and 2 parts of fine silver. For gold of other grades, the proportions of the various metals used in the alloy solders should be varied, always keeping in mind that the solder must melt at a lower temperature than the article upon which it is to be used.

SOLDERING GOLD WORK

Soldering gold articles is not as difficult an operation to accomplish as one would at first think. When the proper solder is obtained, it is very necessary that the articles to be joined be held firmly in contact by iron wire, which is usually used. The contact surfaces are scraped perfectly clean, all bur being removed as well. When in the desired position the joint should be charged with a paste made from a lump of borax rubbed up with water on a clean slate. This paste should be about of a milk-like consistency for gold solders, but for silver solders, it should be quite as thick as cream. When the joint has been charged with borax paste, the solder is added, care being taken not to add too much, heat with a blowpipe until the solder runs. The heat should be applied gently at first, for the borax will swell up and will likely shift the solder from the desired position, causing much trouble and annoyance. It is well to use small pieces of the solder for small work, as they will act more readily than with one larger piece. It is highly important that upon cleanliness of all materials the success of the soldering depends, that is, if the heat is correctly applied. Solder will always run toward the point of greatest heat.

SOLDERING WITHOUT THE AID OF HEAT, OR "COLD" SOLDERING

This process is sometimes used upon articles which will not stand or which for any reason cannot be heated to the temperature necessary to melt the solder. Sometimes the work cannot be reasonably reached with a soldering copper or a blowpipe flame, it is in such cases that the cold process is resorted to and will usually make a good serviceable and strong joint. This cold method can even be used in joining two surfaces of dirty cast iron together. The materials used for this work can be made up in large quantities if desired; the first preparation is tedious, but the actual soldering is simple and quick. For a flux use metallic sodium, 1 part to 50 or 60 parts of mercury; this must be kept in a well stoppered, preferably a ground glass stoppered bottle, to keep it from the action of the outside air. This combination has the property of amalgamating (equivalent to tinning by heat) any metallic surface, cast iron included. The metallic sodium alloys with the mercury by being shaken up in a bottle. If you lack confidence to prepare these materials, they may be purchased from a good supply house handling chemicals or soldering materials. For the solder make a weak solution of sulphate of copper (10 oz. to 1 qt. of water). The copper may be precipitated by the aid of rods of zinc; after precipitation, the copper must be washed two or three times with hot water, then drain off the water, add for every 3 oz. of precipitate 6 or 7 oz. of mercury; a little sulphuric acid should be added to assist the combination of the two metals. The finely divided copper combines with the mercury and they form a paste, which sets very hard in a few hours. While still soft, this paste should be formed into small pellets, which harden and have the property of softening by heat and again hardening in a few hours. When the solder is to be used heat one of the pellets until the mercury oozes out from the surface in small beads, wipe these off, and rub the pellet into a soft paste in a small mortar and pestle, or by any other convenient means, until it is as soft as white lead. The surface to be united should be treated with the sodium and mercury and the solder applied being pressed firmly together will harden perfectly in three or four hours. If it is desirable for any reason to part the joint, it may be accomplished by a hammer and cold chisel or the article, if it will stand the heat, may be heated to a temperature sufficient to melt plumber's solder. One point which has been before mentioned, should be always kept in the workman's mind; cleanliness in all the materials used in soldering and brazing is of the highest importance, and only by observing this rule can the best results be obtained. Judgment as to the amount and quality of the solder or flux for any class of work is of great importance, and, as before said, too much solder upon a piece of work will often cause an unsightly job and reflect discredit upon the workman.

IN CLOSING

There are countless alloys, fluxes and tools for soldering and brazing, a description of which would fill a large book, it has been the aim of the writer of this article to give to the reader a description of the simpler methods and those which have given the best results with the simplest and most inexpensive materials.

An aristocrat is one who is clean,—clean in body, mind and spirit.

Nature intended that men should help each other rather than fight each other.

Anger is a human boiler explosion,—it is not only a waste of energy, but it destroys the container of the energy.

WIRELESS TELEGRAPHY

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

NOTES ON THE OPERATION OF INDUCTIVELY COUPLED RECEIVING SETS IN WIRELESS TELEGRAPHY

LT. J. O. MAUBORGNE

In view of the fact that I have been able to find no literature regarding the action and operation of the inductive tuner other than a few brief sentences advising that an instrument of this nature cuts down the static and affords a means of cutting out unwanted signals; in other words, gives a greater selectivity than can be attained with the direct-coupled type of tuner, due to the fact that the coupling between the primary and the secondary can be varied, I have undertaken the examination of the action of one of these inductive tuners, with a view to determining the practical way of using one of these tuners, either alone, or in conjunction with one or more variable air condensers placed in the circuit, for purposes very well understood by students of the theory and practice of wireless telegraphy.

My original plan for pursuing this investigation has had to be curtailed for lack of time, with a result that the ground has not been covered as completely as might be desired, but the results of the investigations up to date are set forth herein, and may be taken for what they are worth.

DESCRIPTION OF APPARATUS

Inductive tuner consisted of a primary of 100 turns of No. 18 enameled copper wire closely wound on a hollow cylinder 5 in. in diameter, with a sliding contact for the purpose of varying this primary inductance. The secondary, also, was wound with enameled copper wire, and tapped so as to give four steps of inductance, having 25, 50, 90 and 210 turns, respectively, with the necessary switch for cutting in the desired number of turns. The sliding primary contact slid over a scale divided into 40 equal parts, each scale division giving 2½ turns of inductance.

In the diagrams shown herewith, "Primary 20" means that the slider stood at "20" on the primary scale, corresponding to 50 turns of wire. "Secondary 210," or "Secondary 90," in this paper, means that "210" or "90," as the case might have been, were used in the secondary.

Realizing the difficulty of using any scale showing actual coefficients of coupling, since the position of maximum coupling shifts as the number of turns in the primary is varied, an empirical scale divided into tenths of inches and having sixty-three and a half such divisions (this being the actual distance in tenths of inches which the secondary coil could be withdrawn from the primary), was placed on the baseboard of the tuner so that the secondary would slide over it, and when the secondary was completely covered by the whole primary the scale was adjusted to read 63.5, while with the loosest possible coupling between the coils the scale read "0." "Coupling 20," therefore, when used in connection with this paper means that the secondary has been withdrawn from the primary until the coupling scale showed "20." This should be carefully borne in mind, since the coupling plays a most important part in the operation of an inductive tuner.

The sending device used in making this analysis of mode of operation of this tuner, was a Telefunken wave-meter, which is so arranged that waves of any length from 300 to 3,300 meters can be sent out at will. By means of this wave-meter, the circuit was examined under the conditions later enumerated, and the results of this examination in the shape of curves were plotted, and will be examined critically and in detail.

The plan included the mode of operation of the following instruments or combinations of instruments:

1. The inductive tuner alone.
2. The inductive tuner with a variable air condenser in the secondary circuit for the purpose of tuning it.
3. The inductive tuner using a variable air condenser in series with the primary of the tuner. Secondary circuit untunable.
4. The inductive tuner having a variable air condenser in parallel with the primary of the tuner. Secondary circuit untunable.

Combinations "3" and "4" were to have been examined in conjunction with a tuned secondary circuit, but time did not permit this.

The variable air condenser which was used in case "2" to shunt the secondary was one having a maximum capacity of .005 mfds., while the condenser used in the primary circuit in cases "3" and "4" was a small Telefunken variable air condenser with a capacity of about .0015 mfds. The antenna was the regular umbrella type, Signal Corps pack set kind, having a 40 ft. pole and a rubber insulated counterpoise, thrown on the ground.

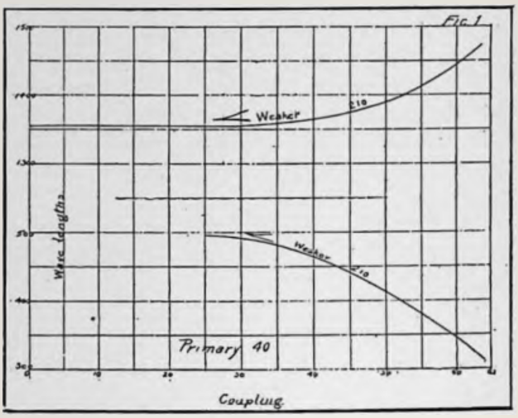
It is to be understood that the curves found in these experiments, so far as actual wave-lengths are concerned, apply to this particular set of instruments only; that, if the same instruments were measured when attached to a different aerial, the wave-lengths obtained would have been different, but that the general mode of operation of all inductive receiving sets will be the same, and the principles derived from these experiments apply to all inductive receiving sets, regardless of their size, or the antenna to which they may be attached.

By way of prelude we may say that two circuits which are inductively connected, will have a maximum coefficient of coupling when the turns of the primary coil, no matter what may be their number, are so placed that they are exactly over the center of the secondary coil; "center," in this case, referring to the point on the length of the coil midway between its two ends.

This may be verified by measuring the self and mutual inductances, and computing the coefficients of coupling for a given series of positions of the primary and secondary coils with reference to each other.

Furthermore, we may add, that the particular tuner used in these experiments, like most inductive tuners constructed at the present day, had its primary so wound, that, if the turns in the primary were few, the secondary coil could pass beyond the point of maximum coupling in either direction; hence, there would be two positions of the secondary coil with respect to the primary, where the coefficient of coupling would have the same value. Without a thorough understanding of this principle of construction, some of the deductions from the form of the coupling curves shown may not be readily understood.

Case 1. *The inductive tuner alone.*—The very first measurements made gave the two curves shown in Fig. 1.



These curves were obtained as follows:

The primary slider throughout the measurements which resulted in the production of the curves in this figure was kept at the point marked "40" on the scale—in other words the whole inductance of the primary was in circuit with the aerial and counterpoise. The curves are marked "210"—which means that 210 turns, or the whole secondary, was in circuit with the silicon detector and small stopping condenser. The only variable element in this case, was the coupling.

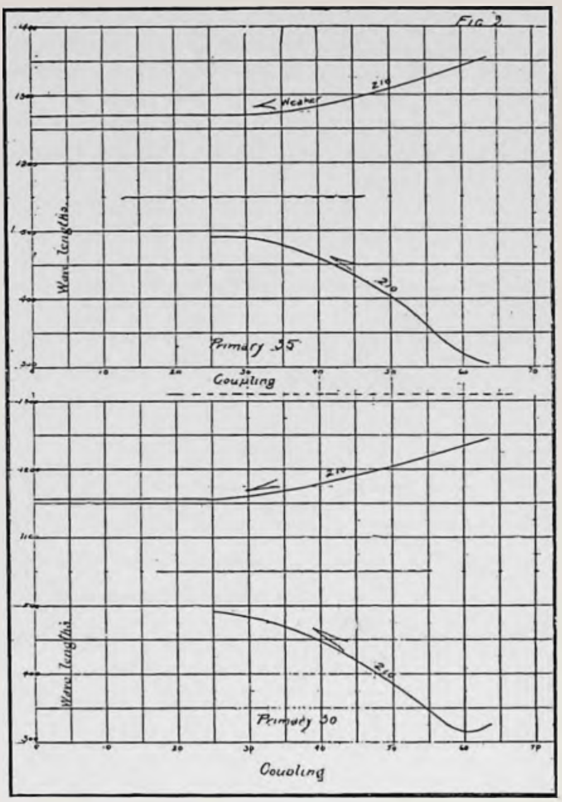
It is evident that with an inductive tuner alone, there are but three variable quantities by which tuning may be affected, viz., the inductance of the primary, the inductance of the secondary, and the coupling of the coils.

In this first experiment the primary and secondary were not varied, but only the coupling. The first very important deduction concerning the action of the inductive tuner can now be made after an examination of the curves in Fig. 1. *Varying the coupling varies the wave-length.*

The second important fact which is shown by Fig. 1 is that *no matter what coupling we use we are always tuned to two wave-lengths at the same time.* For example, by referring to this figure, we see that when the coupling is 63.5, or as close as possible, we are tuned to both a 1,450 and a 315 meter wave at the same time. Similarly, further down the curve, let us say when we have pulled the secondary coil out until the coupling scale reads "30," we find that we are tuned to both a 1,355 and a 490 meter wave.

Questions immediately crowd upon us. Why the double periodicity? Is it not detrimental to our best interests to be tuned to two waves when we desire to be tuned to only one?

If we remember that in our sending set, closely coupling the closed and open oscillatory circuits together, even if they be in resonance with each other, causes the station to send out two waves, one of which is greater and the other less than the wave-length to which both circuits were individually tuned, we are forced, by the likeness of the sending inductance to the inductive tuner we are using for receiving, and by the fact that the set is in resonance with two different wave-lengths at once, and that we change both of these periods by changing the coupling between the coils, we are forced, I repeat, to the conclusion that, notwithstanding the hitherto common opinion that the secondary circuit, used as we are using it here, is untuned, that this circuit is really a tuned circuit after all, and if measured by itself would show that this circuit has a definite period of its own. This can be experimentally proved to be so by disconnecting the aerial and counterpoise from the primary, and by means of the Telefunken wave-meter, measuring the wave-length of the secondary, notwithstanding the fact that the resistance in the circuit must be far greater than twice the square root of L over C. Measurements made showed that though the resonance was dull, the 210 turn secondary had a wave-length of 520 meters, and that for 90 turns the wave-length was 409, and for 50 turns, 375 meters. The resistance in the circuit was very high—the telephone receivers alone being 8,000 ohms without the resistance of the detector.

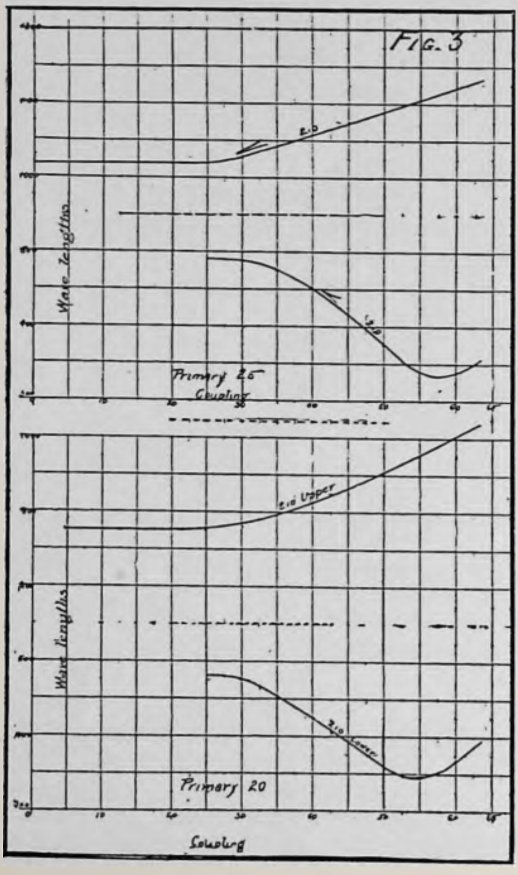


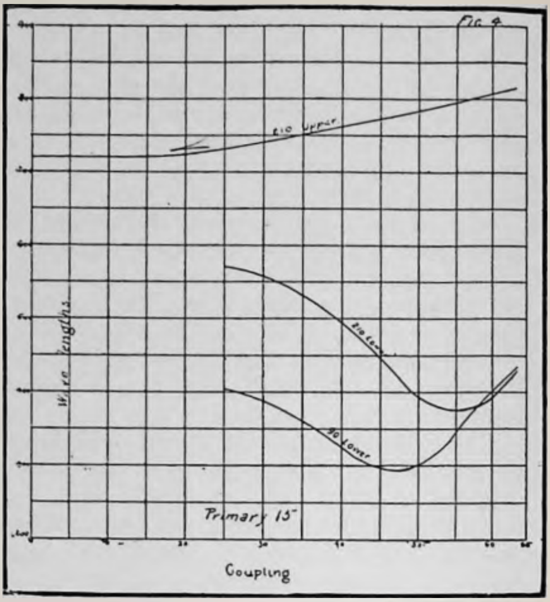
It occurred to me that if I were to remove the telephone receivers from around the stopping condenser, and put them around the detector instead, I would, by thus putting the receivers in parallel with the detector, cut down the resistance in the circuit, and add the value of the stopping condenser to the circuit, and, in that way, increase the period of the secondary circuit. This was done, and the circuit was remeasured with the wave-meter, and the following values of lambda obtained; for circuit with 210 turns in secondary, 1,085 meters (it was 520 before); for 90 turns, 637 meters, and for 50 turns, 448 meters. If, now, this secondary, with the receivers around the detector instead of around the stopping condenser, were coupled inductively to the primary circuit, we ought to get two periods as before, the greater one being greater, however, than the larger period obtained in the original experiment. This was confirmed by measurements made with the wave-meter.

However, in order that the experiments should all be made under the same conditions, the telephone receivers were again placed around the stopping condenser where they remained during the experiments which followed.

The question of interference caused by the double periodicity will be taken up again later.

Figs. 2, 3, 4, 5 and 6 were then obtained by decreasing the primary inductance by steps, then leaving the value of the primary inductance constant, plotting the two curves due to the change of coupling while the secondary inductance was kept constant at 210 turns, or later replaced by a secondary of 90 or even 50 turns, in order to determine what would happen if the secondary were reduced, the primary being kept constant.





A careful study of these curves will go far to understanding how these tuners should be operated to produce the best results at the receiving station. The curves should be studied by making comparison between the upper curve for any given primary and secondary and the lower curves for the same combination, and between all the lower curves considered at once, as well as between all the upper curves.

A careful examination of them will show the following to be true:

Decrease the inductance of the primary, the secondary and coupling remaining unchanged, decreases the wave-length shown by the upper curves, and *vice versa*.

Decreasing the coupling, with a given fixed value of primary and secondary, causes the wave-lengths shown by the upper curves to decrease. The wave-lengths shown by the lower curves will decrease until the point of maximum coupling is reached, when they will increase. Thus it is seen that it is possible to pick up a given station having a small wave-length in two different places while the coupling is being varied from 63.5 to zero, due to the fact that the coefficient of coupling is the same for two certain positions of the secondary coil with reference to the primary.

Loosening the coupling tends to bring both periods nearer to the natural period of each circuit, and, *vice versa*, the tightest coupling drives the two periods farther apart.

Decreasing the inductance of the secondary decreases the wave-lengths of both curves—see Fig. 5.

Would the double periodicity be a cause of interference if we were trying to tune to a single wave-length? Unquestionably so, unless we change the lower wave-length to which we are tuned without changing the upper wave-length. It is seen from Figs. 1 to 6, inclusive, that the lower curve runs almost entirely through the most thickly populated part of the æther. There are probably more stations using wave-lengths between 300 and 600 meters than in any other place in the scale.

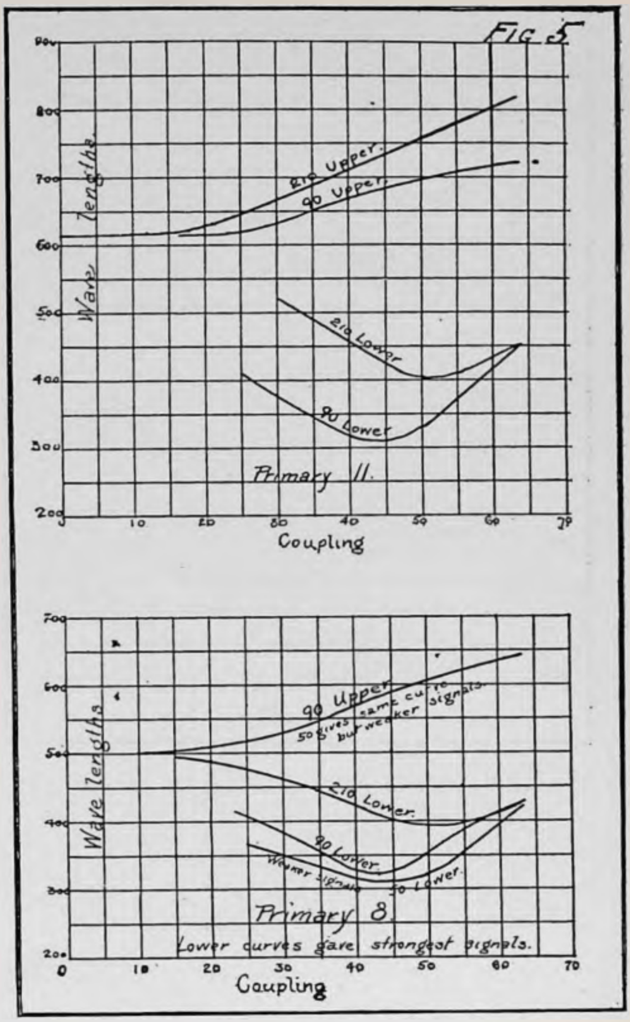
In order to get rid of some station of small caliber operating in the lower register, while we wish to listen to some station we find on the upper curve, all we have to do is to change the inductance in the primary circuit, and change the coupling, and we will get rid of the undesired station without losing the other one.

This subject will be discussed in full under Case 3.

Interference is of many kinds, that of "static" being one of the worst. *Static is gotten rid of to a great extent by using an inductive tuner loosely coupled.*

A second ago we discussed very briefly and dismissed for awhile the subject of tuning out a station having a wave-length different from the wave-length of the station to which we are listening.

Suppose the interference comes from a station sending with a period similar to our sending station, and coming in as strong as he. If we could tune to both humps of our sending station, if he were sending out a double-humped wave, we might be able to increase the energy received to such an extent as to give us



a preponderance of sound in favor of our own sending station.

What is necessary that we may be able to tune to both humps of a closely-coupled station? Our secondary circuit must be capable of being adjusted to resonance with our primary circuit, and the coupling varied until the receiving set has the same coefficient of coupling, the two circuits having been adjusted to the same period as that to which the circuits of the sending station had been adjusted.

Is this possible with a tuner used alone as this one is?

There are evidently only as many cases where this can take place with the untuned secondary as there are steps of inductance in the secondary, and then only when we tune our primary to the

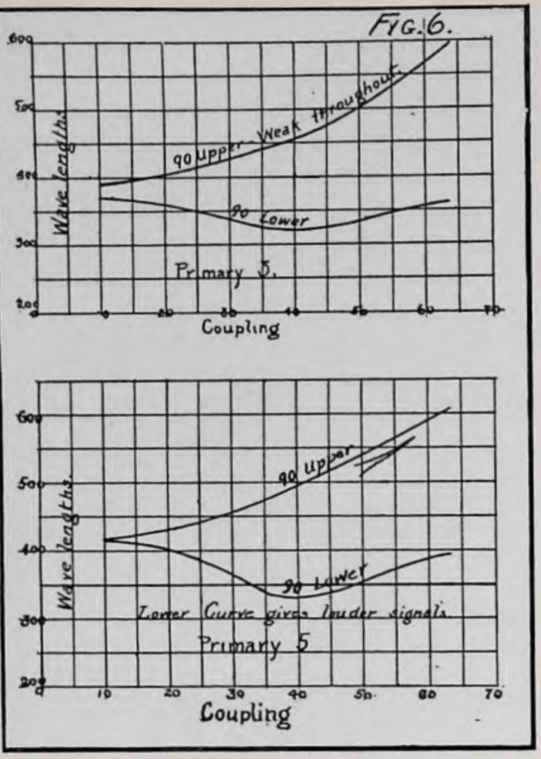


FIG. 6.

same wave-length as our secondary, and loosely couple.

Fig. 6 shows one case of the four possible with this tuner. This tuner then, without some means of tuning the secondary is of little value for this purpose.

If, instead of having to tune to two wave-lengths we only have to tune to one and do not want to be bothered by any station on the lower hump, what means have we to do so? It is evident that this, too, cannot be done with the tuner alone, so we will discuss this question later.

Let us now go back to the question of how we are going to dodge the fellow with the same wave-length as our sending station who comes in louder or at least as loud as it does. Of course, if there is any difference in pitch between the notes of the two stations, or some other peculiarity of spark, it is easy for the skilled operator to concentrate his thoughts on what one is saying to the exclusion of the other. This is quite frequently done in practice. But why be bothered by the other station at all if there is some way of getting around the difficulty? My solution is as follows: Let us adopt for our pack sets and other portable stations a wave-length of such size that no other fellow will be using it unless he does so to bother us. The list of the wireless telegraph stations of the world, and our knowledge of the wave-lengths of amateur stations shows us that not more than a half dozen stations in the world today are using wave-lengths between 650 and 900 meters. Why can we not add a loading coil or two to our sending set and send out waves between those limits and never be bothered, except intentionally, by a fellow having the same wave-length as our stations? This looks like a reasonable proposition. I should like to see it tried.

General summary of remarks concerning tuning with inductive tuner alone. *In general, if not bothered by any station working on a shorter wave than that used by the station to which we are trying to tune, such adjustments of the primary and secondary as will enable you to pick up the desired station with the loosest possible coupling of the inductive tuner.*

Since it will, in general, be impossible with a tuner alone to tune to a double

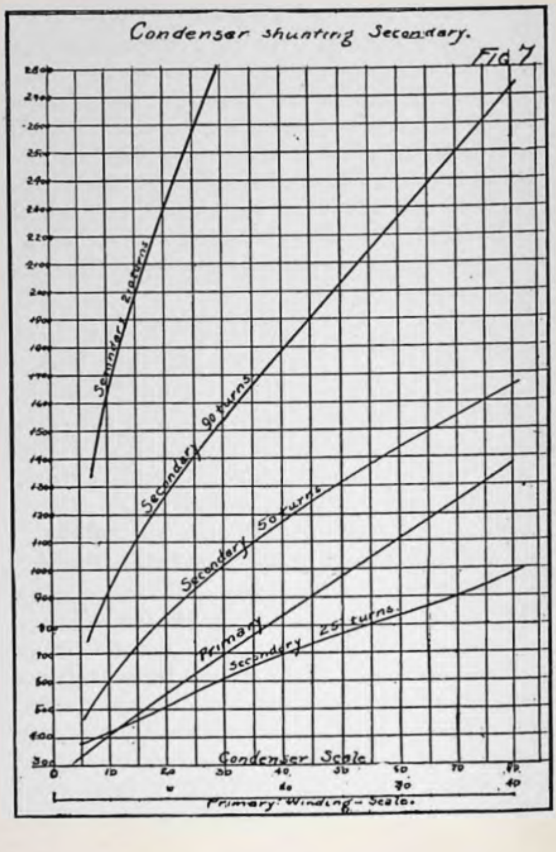


FIG. 7

humped wave, *tune for the longer wave which is usually the least damped.*

For *long waves*, increasing the primary increases the wave-length.

For *long waves, increasing the coupling increases the wave-length.*

For long waves, use the full secondary inductance and large amounts of primary, and fairly close coupling.

For short waves, use small amounts of primary and secondary and very loose coupling.

The longest wave-length for any inductive tuner used alone is obtained when the primary and secondary inductances are a maximum and the coupling as close as possible.

CASE 2

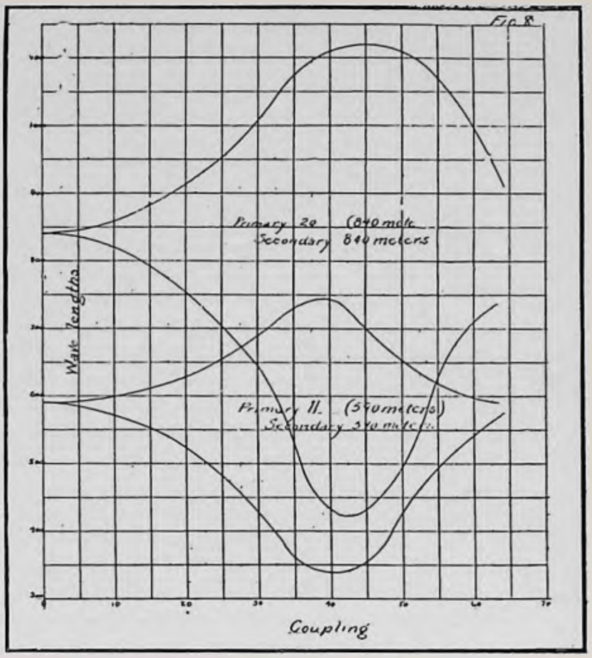
Same apparatus as in Case 1 except that the secondary circuit is now tuned by means of a variable condenser placed across the terminals of the secondary coil.

The idea in this case is to put the secondary in resonance with the primary, and in this manner to make the primary act upon the secondary at a greater distance than before, due to the well-known rise of the current at resonance.

This method enables the operator to do two things he could not do with the apparatus in Case 1. He can tune to a single wave-length without being bothered by any other; he can tune to both humps of a sending station and get an increase of energy in that way—and due to the greatly decreased coupling at which he can get audible signals can cut out most of the static, which is a great argument in favor of the use of this system if there were no others.

In order to use this apparatus intelligently, however, it will be necessary for him to calibrate his primary and secondary circuits so as to know what combinations to make to get certain wave-lengths. Fig. 7 shows this calibration made for the instruments we have used in this experiment. The diagram is self-explanatory.

One word of caution. The variable condenser should not be over .001 mfd., and the tuner should be constructed so that this capacity can be coupled with small quantities of inductance in the secondary. So the secondary should



have a tap at 25 or 30 turns so as to be able to tune to small wave-lengths.

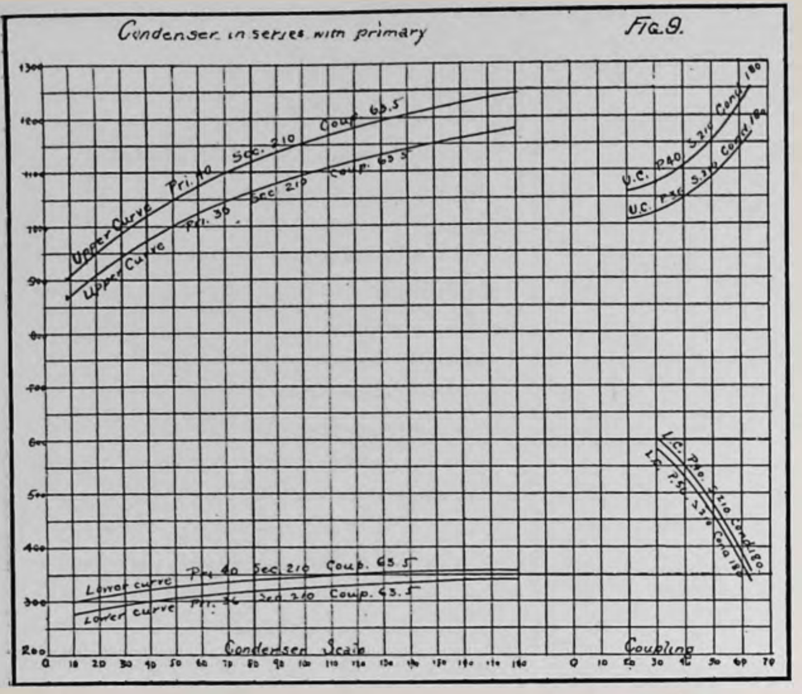
From Fig. 8, which shows the effect of increasing the coupling of two circuits tuned to the same period, it is evident that if we knew the fundamental wave-length to which a station was tuned before its circuits were coupled together, we can tune our circuits both to that same wave-length, and then by starting from a position of very loose coupling, if we gradually increase the coupling until we get the same coefficient of coupling as that used at the sending station it is evident that we will be tuned to both humps and will receive more energy than when tuned to only one of them. Also, we will be tuned to only a single wave-length if we tune both of our circuits to the same wave-length and loosely couple.

The loss of energy is so small as to be unappreciable. This I have determined by listening to distant stations.

CASE 3

A variable condenser is in series with the primary inductance, and secondary circuit untuned as in Case 1.

Referring to Fig. 9, it is at once evident that decreasing the variable capacity decreases the wave-lengths of both upper and lower curves, and by this

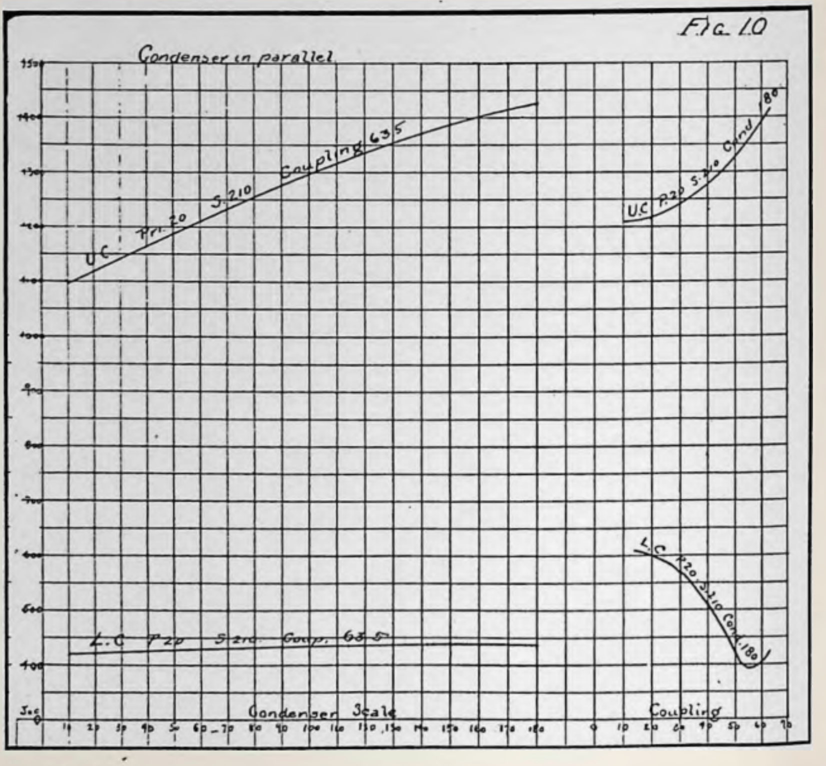


means we can reach wave-lengths smaller than the normal wave-lengths we can get with inductive tuner alone.

The curves of coupling also show, that with a fixed primary, secondary and capacity, loosening the coupling causes a rapid drop in the wave-lengths of the upper curve, and a rapid rise of the wave-lengths of the lower curve. *This gives a means of cutting out an undesirable station operating with short wave-length.*

Looking at Fig. 9, if we are desirous of picking up a station with 1,100 meter wave-length, and find him with the combination primary 40, secondary 210, coupling 63.5 and condenser 70, only to find to our disgust that some amateur is sending out a 335 meter wave and getting in his work on our lower hump, all we have to do to get rid of him is to increase the wave-length of the primary circuit, which we may do in this case by turning the condenser to 180 degrees.

This gives us a wave-length of 1,245 meters, and we have lost our own station for a moment, but if we then loosen up the coupling until we reach 38 on the coupling scale we get him again. This movement of the secondary which has caused the upper curve to fall has caused a rapid rise in the lower curve and we have gotten rid of our 335 meter man, for our lower hump is now tuned to 560 meters.



A great many variations of this principle will make themselves clear to the reader, without further explanation, and it is thus seen that this device becomes in the hands of a man who understands it, extremely selective.

To state the last case very briefly, it is that of the inductive tuner with untuned secondary, but has a condenser in parallel, instead of in series with the primary.

The curves have the same general characteristics as those of the previous case except that the use of the capacity in parallel enables us to get wave-lengths greater than those which can be reached normally by the tuner alone. Compare Fig. 10 with Fig. 3.

The method of tuning out undesirable stations is the same as in the previous case.

The most selective device would undoubtedly be one consisting of an inductive tuner whose primary is variable by single turns with a variable condenser which may be thrown either in series or in parallel with the primary, and a variable condenser of small value around the secondary.—(Conference No. 14, *Army Signal School.*)

THE RELATIVE COST OF DRILLING

A. S. ATKINSON

If there is any one question in mining more difficult to answer satisfactorily in advance than the relative cost of drilling it has not yet come prominently to the attention of engineers. There are so many conditions governing the problem that the data furnished by one mine may be almost entirely worthless for application to another. Each problem must, therefore, be one whose solution depends chiefly upon local conditions.

Nevertheless, to a certain extent, there are standard rules and results which can at least be depended upon to guide one, both in making estimations and in performing the work. Drilling has been greatly improved in recent years, and results are obtained today never dreamed of a decade or two ago. Not only is time saved, but labor and cost, too. The electric drill has come into use to compete with the steam-driven and compressed air drills, and in these three we have efficient machines that are suitable for about every known condition found in or above the mines. Hand drilling may still have its limited application, but machine drilling has rapidly displaced it in all of our mines of importance.

Diamond drilling has performed wonders in the last quarter of a century in reaching down to depths that are almost inconceivable. The greatest depths reached by drills are in the Transvaal gold fields of South Africa, where persistent efforts have been made to follow the gold reefs at increasing distances from the surface. Within the last ten years a number of holes were drilled to depths ranging from 3,500 to 5,000 ft., and three at least have gone to depths of more than a mile. These extremely deep holes were respectively 5,560, 5,582 and 6,340 ft. The great cost and labor of making such enormous depths can be judged partly by the fact that a mile of rods, in 50 ft. sections with double sheaves, would require from eight to ten hours of constant labor for removal from the hole.

In mining in the Cripple Creek district in Colorado, a number of rock drills reached far below the 1,000 ft. mark, and in Nova Scotia during the past year prospecting core drills were driven down to 1,600 and 2,300 ft. In the Michigan and Arizona copper districts holes have been drilled to depths varying from 1,500 to 3,200 ft. Apparently there is no limit to deep drilling if the proper equipment and outfit are provided. But such deep drilling is not of general value except for prospecting purposes, although in some mines deep drilling has become a permanent feature of the work.

In Nova Scotia where deep drilling has been going on for some time the cost per foot has varied from 81 cents to $1.34. This was with diamond drills operated at depths varying from a few feet to a thousand and more. But even here where deep drilling has been carried on for some time the actual cost varied a good deal. When boring through soft rock under ideal conditions the cost reached as low as 47 cents per foot, and at other times when hard layers of rock were encountered, the cost reached as high as $1.71 per foot.

In installing a plant for drilling the number and size of the drills required to do the work must first be estimated, and when the maximum of drills to be run has been determined the capacity of the power plant can be worked out. The size of the drills must be determined by the material to be drilled, whether soft, medium or hard, and also the depth of the holes. The number of the drills is determined by the size of the undertaking and the rapidity with which the work is to be done and the advantages obtained by having a great number of drills in operation at once.

If compressed air is to be used the size and power of the compressor must be worked out mathematically to secure the greatest economy and efficiency. For sea level drilling a pressure of 80 lbs. to the square inch is most commonly used, and this gives on the average the most economical results. But some use for this work as low as 60 lbs. pressure, and others use 90 and more, but as a rule a pressure above 100 lbs. cannot be economically used. The reason for this is that the frequent sharpening and changing of bits, due to the rapidity and vibration, causes too much loss of time and labor.

The problem of carrying the compressed air any great distances must be considered also. As a rule, there is less loss in this than some suppose. If the line is properly constructed the losses do not exceed much more than 3 to 5 lbs. in pressure in lines of 5,000 to 10,000 ft.

The electric drill now used in many mines has some advantages for special work over all others. It is the most flexible power for drilling, and it can reach parts of a mine where it is difficult to run the air pipes. Where electric power is used for hoisting and lighting the operation of drills by the same power is simplified. The requisite amount of power demanded for any time of the day is always ready, and there is constantly a uniformity of operation that makes for economy.

A factor in all kinds of drilling not always considered in full is the cost of drill repairs. When boring through hard rocks with a great number of drills this repair and sharpening of drills becomes a pretty formidable factor. This problem has assumed such proportions in the Calumet & Hecla mines that a special drill sharpening plant has been established. In this plant, approximately 4,000 drills are sharpened a day from 300 different drilling machines. The sharpening plant is the most extensive and complete of any in the country, but it shows the methods that are being adopted by many companies where a great number of drills are constantly being operated.

In this plant the drills are carried by a belt conveyor to a heating forge where they are removed by hand and placed upon a chain conveyor. This carries them in a rotating motion through the heating forge which is fed by crude oil under pressure and kept at a temperature of about 2,000 degrees F. Each drill is kept about three minutes in the forge before it is dropped into a movable apron which slides it automatically into position in the sharpener. The sharpener consists of a hammer of 5 lbs. in the form of a double die which strikes 1,600 blows per minute. The drill, when it falls from the apron, is caught and clamped by the action of an air cylinder. The hammer operating quickly and accurately reduces the end of the bit to a cutting edge and shifts the surplus metal from the center to the edges. Then the bit passes on to the upsetting machine which restores the diameter of the drill and cuts the edges into a plane at right angles to the horizontal axis of the drill. This is accomplished by a few blows with a piston carrying a die. Then the drill passes on to the fluter which is an 800 lb. steam drop hammer with a stationary die attached. Two blows of this hammer are sufficient to straighten the vanes of the drill to standard thickness. The sizing machine next receives the drill, and finally it goes to another forge where it is tempered and finished. It is dropped from this into a tank of cold water, and finally by a conveyor back to where it started. The whole process works automatically, and the dullest

(*Concluded on page* 211)

SHAFTING

Materials, Strength and Equipment

Materials most commonly used in making shafting are wrought iron and steel, though in some cases where the shaft is short and well supported, such as jack shafts, cast iron is employed. Originally, shafts were made of wood, but today these are rare and represent only the crudest sort of means for transmitting power. It is, therefore, within the scope of this article to take up a discussion of wrought iron and steel shafting only, as these are the only materials employed for transmitting power to any distance, says *Practical Engineer*.

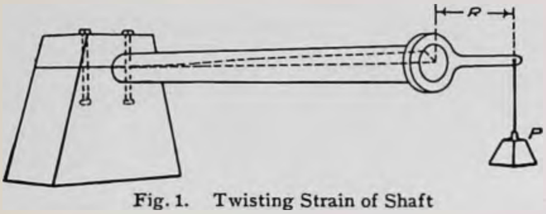


Fig. 1. Twisting Strain of Shaft

The choice between wrought iron and steel lies largely with the fancy of the engineer, though for shafting transmitting a small amount of power, wrought iron is almost invariably used, as the diameter of a steel shaft would be so small that it would become impracticable, owing to the increased number of supports needed, or if the diameter be increased beyond that necessary to carry the required power its cost would be increased so much more than wrought iron that it would become impracticable from this standpoint. At the other extreme, that is, where a great amount of power is to be transmitted, steel shafting is employed, as its diameter and weight will be considerably less than that of wrought iron for the same power transmitted.

TWISTING LOAD

Strains to which a shaft is subjected come under two heads. These are the twisting and bending strains. The principal strain, of course, is that due to the twisting action of the pulley, and a study of its action in detail is essential, in order that we may get a clear conception of what is actually taking place within the fibers of the shafting, and thus be able to determine the power which the shaft is able to transmit.

Considering a shaft that is fixed rigidly at one end, and at the other has a horizontal lever attached to it whose length is R. At the end of this lever is attached a weight P. This arrangement is shown in Fig. 1. It will be seen that in order to keep the shaft from twisting, the fibers of the shaft must exert a combined moment of force equal to the product of R times P.

Suppose that the strain put upon a very small unit of area of the shaft A (Fig. 1) to be p, then the resisting moment of this area is equal to p times its distance from the center of the shaft. From this it is evident that the resisting moment of a unit area of the shaft is proportional to its distance from the center, and by mathematical calculation it has been shown that for round shafts the total resisting moment becomes 3.1416 times the shearing strength of the material used, times the cube of the diameter, divided by 16. By means of this rule we are therefore able to determine the power which the shaft will transmit, knowing the radius of the pulley and the shaft diameter, the shearing strength of steel being 75,000 lbs. to the square inch; of wrought iron, 50,000 lbs., and of cast iron, 25,000. Furthermore, if we know the speed of the shaft we are able to determine the horse-power transmitted by multiplying the pull in pounds by the speed of the belt in feet per minute, and dividing the product by 33,000.

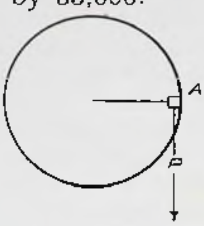


Fig. 2. Strain on Small Aria

The rule above gives the breaking strength of the shaft, for we took the ultimate shearing strength of the material used in the shaft, so for our purposes, it is necessary to use a shearing strength considerably less, in order to get a safe working strain. This for steel is taken as 12,000 lbs., for wrought iron 8,000, and for cast iron, 4,000.

Taking these factors into consideration, in the above rule, we find the diameter of the shaft by dividing the horsepower to be transmitted by the revolutions per minute, extracting the cube root and multiplying by 2.984 for steel; for iron, multiply by 3.422, and for cast iron by 4.297.

In order to get this rule into a working form the diagrams in the practical tables have been worked out for various horsepowers and speeds to give the diameter of shaft necessary.

Thus, knowing two of these three quantities, by the use of the diagrams, the other dimensions can easily be obtained. In these diagrams, however, a larger factor of safety has been used in order to take care of the bending strain. For cold rolled iron the multiplier used for shafts with bearings on 8 ft. centers is 3.68, and for turned iron under the same condition the multiplier used is 4.48, these values being given by several authorities as representing best practice.

TABLE 1. GREATEST ALLOWABLE DISTANCE BETWEEN SHAFT BEARINGS

DIAM. OF SHAFT IN IN.	DISTANCE BETWEEN BEARING, FT.	
	WROUGHT IRON	STEEL
2	15.46	15.89
3	17.70	18.19
4	19.48	20.02
5	20.99	21.57
6	22.30	22.92
7	23.48	24.13
8	24.55	25.23
9	25.53	26.24

TABLE 2. DIAMETER OF SHAFT TO CARRY LOAD MIDWAY BETWEEN BEARINGS

DIAM. OF HEAD SHAFT	DIAM. OF SHAFT FOR CARRYING LOAD AT CENTER OF BAY							
	2½ FT.	3 FT.	3½ FT.	4 FT.	5 FT.	6 FT.	8 FT.	10 FT.
IN.	IN.	IN.	IN.	IN.	IN.	IN.	IN.	IN.
2	2⅛	2¼	2⅜	2½	2⅝	2¾	2⅞	3
2½	2½	2⅝	2¾	2⅞	3	3⅛	3⅜	3⅝
3	3	3⅛	3¼	3⅜	3½	3¾	4	4¼
3½		3½	3⅝	3¾	4	4¼	4½	4¾
4		4	4⅛	4¼	4½	4¾	5⅛	5⅜
4½			4½	4⅝	4⅞	5⅛	5½	5⅞
5			5	5⅛	5⅜	5⅝	6	6½
5½				5½	5¾	6	6½	6⅞
6				6	6⅜	6⅝	7⅛	7½

HOLLOW SHAFTING

By an analysis of the strains which take place within a shaft as given above, it will be noted that, since the moment of force which a given area of the shaft is able to transmit varies as its distance from the center, the actual material employed in the shaft can be made less and still transmit the same amount of power by making the shaft hollow. By a comparison of the solid and the hollow shafts it has been demonstrated that they will be of equal strength when the difference between the fourth powers of the outside and inside diameters divided by the outside diameter of the hollow shaft is equal to the cube of the diameter of the solid shaft.

There are certain advantages to be had by the use of hollow shafts in that their weight is considerably less, and for this reason, and also that the bending strength is considerably decreased, owing to the increased diameter, the bearing or the supports can be placed further apart. Where the power is great a hollow shaft becomes so large that the bearings become abnormally large and over expensive.

DISTANCE BETWEEN SUPPORTS

The proper distance between bearings or supports of a shaft is governed by the deflection which should never exceed 0.01 in. per ft. of length. This in turn is dependent upon the weight or diameter of the shaft, the material of which it is made, and the location of the pulleys with reference to the bearings.

Table 1. Greatest Allowable Distance between Shaft Bearings

For simply transmitting power without weight Table 1, computed by J. B. Francis, gives the greatest distance between bearings where iron and steel shafting are employed, the distance being in feet.

Table 2. Diameter of Shaft to Carry Load Midway between Bearings

For ordinary line-shaft work, however, this table is of no value, as it is necessary to place pulleys at various points along the shaft without reference to the bearings. The general rule for line shafts is to place the bearings 8 ft. apart, but Table 2 given by Kent will be of value, as it gives the diameter of shaft necessary to carry the load at the center between bearings, compared with the diameter for head shafting. Expressed as a rule where shafting is used for transmission alone, the distance between bearings is taken as the cube root of the product of 720 times the diameter squared. Where the shaft carries a number of pulleys placed at various points between bearings, the distance is equal to the cube root of (140 times the diameter squared).

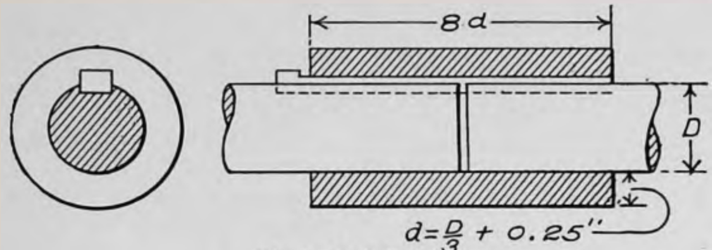


Fig. 3. Muff Coupling

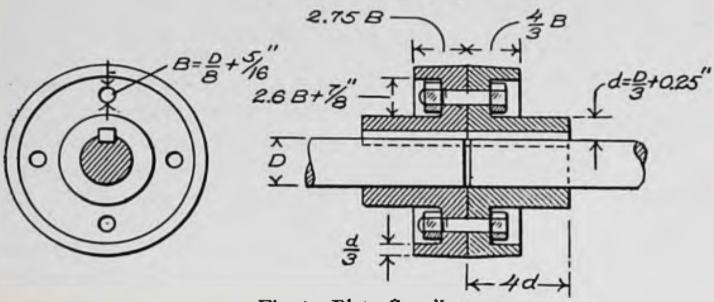


Fig. 4. Plate Coupling

PROPER SPEED

The character of the work to be performed by a line shaft determines almost entirely the speed at which it should be driven. Another factor entering into the choice of speed is the speed of the main driver and the diameter of the main driven pulley.

For machine shops the speed most generally employed ranges between 120 and 180 revolutions per minute. In woodworking shops this is increased from 250 to 300 revolutions per minute, and in cotton mills and the like, the line shafts run from 300 to 400 revolutions per minute.

While it is less expensive to install a plant with line shafting running at high speed, owing to the decreased cost of shafting, belts, pulleys, etc., the cost of maintenance is increased considerably, owing to the increased wear upon the bearings, the vibration of the shaft tends to destroy its alignment, and the general wear and tear of the whole system increases.

COUPLINGS

Where it is found desirable to extend a shaft or in case where the shafting runs the entire length of the room without sufficient space at the end to remove pulleys, clutches and the like, some form of coupling is a convenience well worth employing. There are upon the market a large number of different styles of couplings, but they all may be considered under one of the following five types.

Muff couplings, as the name would imply, consist of simply a ring which slips over the adjoining ends of the two shafts, the joint being fitted with a key which runs the entire length of the coupling. The thickness *d* of the hub, Fig. 3, is equal to one-third the diameter of the shaft plus 0.25 in., and the length of the muff is eight times the thickness.

Plate couplings, such as shown in Fig. 4, are used for heavy shafts and consist of two parts, each keyed to the end of a shaft with the flanges bolted together. The thickness of the hub equals one-third the diameter plus 0.25 in., the same as for the muff coupling, and the length of the hub equals four times the thickness, this being for each half of the coupling. The halves are either forced or keyed to the shaft before it is put into place, and after alignment has been made the plates are bolted together. The number of bolts employed equals 0.8 times the diameter of the shaft plus 2.

Forged flange couplings are made by upsetting the end of the shaft so as to form a disk at the end whose diameter, according to Seaton, is equal to 1.6 times the diameter of the shaft plus 2.25 times the diameter of the bolt used. The diameter of the bolt circle equals 1.6 times the diameter of the shaft, and the thickness of each flange equals 0.3 times the diameter of the shaft.

The double cone coupling shown in Fig. 6, is somewhat more complicated in its construction than any of the foregoing, but presents the advantage that it is easily removable and allows for some variation in the diameter of the shafts upon which it may be placed. It consists of two hollow split cones which fit into a sleeve whose interior surface is a double cone shaped to conform to the surface of the interior cones. The coupling is provided with three bolts which run the entire length of the coupling, and draw the interior cones together, thus clamping them tightly against the shaft, and as an extra precaution, the coupling is provided with a key which runs its entire length. The illustration shows the dimensions employed, using D as the diameter of the shaft.

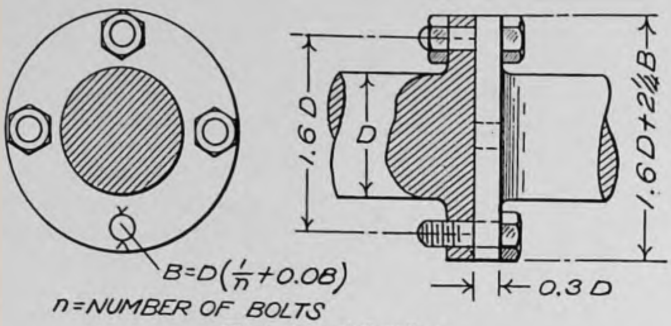


Fig. 5. Forged Couplings

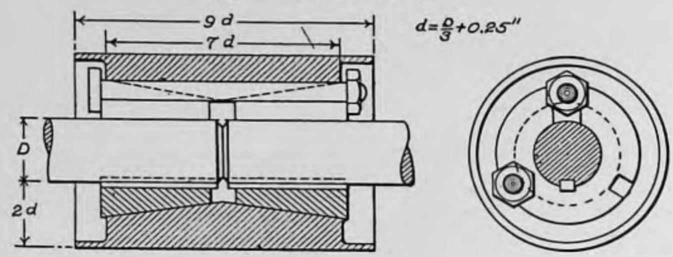


Fig. 6. Double Cone Coupling

Clutch couplings are employed where it is desirable to disengage one section of the shafting from the other, and a general form of cone type of coupling is shown in Fig. 7. The thickness of the hub in this case is the same as that for the muff coupling, being equal to the diameter of the shaft divided by 3, plus 0.25 in. The length of each half of the coupling is also as before, four times the thickness of the hub. The radius of the flange to the contact surface should not be less than three times the diameter of the shaft, and the contact should make an angle not less than 10 degrees, with the center line of the shaft. In this case half of the coupling is forced or keyed to one shaft, while the other is fitted loosely upon the shaft, which is provided with a feather key, and by means of a lever arrangement and toggles, this half of the coupling may be shifted upon the shaft so as to engage or disengage with the other half of the coupling.

Table 3 Key Dimensions for Various Sized Shafts

The installation of a coupling upon a line shaft requires the utmost care to see that the shaft is in perfect alignment, or trouble is sure to follow. There is considerable danger connected with the use of couplings in that there are frequently projecting points such as bolt heads, nuts, etc., which are liable to catch upon belts, thus causing the belt to be ruined, or the alignment of the shaft to be destroyed as well as other serious consequences.

(*To be continued*)

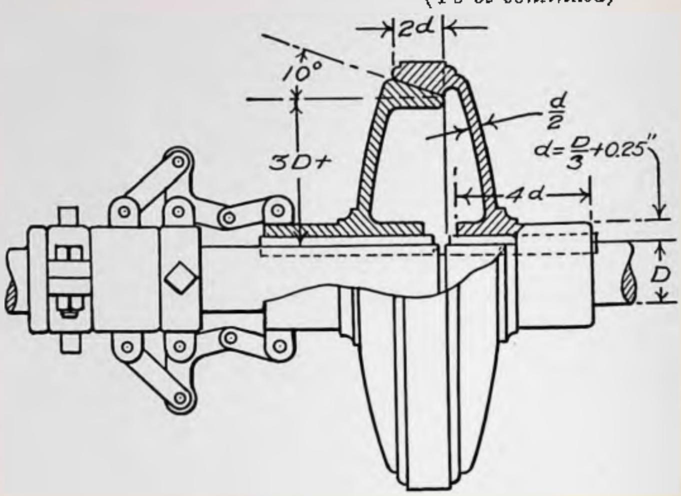


Fig. 7. Cone Clutch Coupling

A SENSIBLE VACUUM CLEANING OUTFIT

LOUIS POTTER

There is a mistaken notion, now widespread, that it is cheaper to use a small power than a large one in vacuum cleaning. For instance, if current costs 10 cents a k.w.h., as is common, a 1/8 h.p. motor will cost about 1½ cents per hour to operate; a ½ h.p. motor will cost probably 5 cents per hour. The ½ h.p cleaner can do work more than twice as quickly, so the comparative costs will be as follows, with labor at 15 cents per hour:

½ hour labor at 15 cents	$0.07½
½ hour current at 5 cents	.02½
Total for ½ h.p.	$0.10
1 hour labor at 15 cents	$0.15
1 hour current at 1½ cents	.01½
Total for 1/8 h.p.	$0.16½

The first requisite in a cleaner is power, in the form of electric motor, human muscle or gasoline engine. Manual labor is usually limited to 1/10 h.p., and this for short continuances. To produce an effective vacuum this is not enough, even when properly applied. This is the reason hand-power machines have not been a success; the power applied to a broom or damp cloth seems to have more effect.

As the electric motor is the only other power suitable for household use, electric cleaners have been put out in large numbers and with more or less success.

Vacuum pumps may be one of four classes, centrifugal pumps, piston pumps, diaphragm pumps or rotary pumps. A centrifugal pump, or fan, operates on the principle of centrifugal force, a substance flying out at a tangent when revolved. When acting on water these fans may reach a considerable suction power, but, with air, or especially rarefied air, the vacuum is so reduced that the best type of centrifugal vacuum pump now on the market only reaches 3 in. or about 1½ lbs. vacuum to the square inch. This is far too little; 10 in. at least should be used. In demonstrations, these fan machines show up to be more than they are worth. Dust or flour is strewn over a carpet and the tool is run over it. The

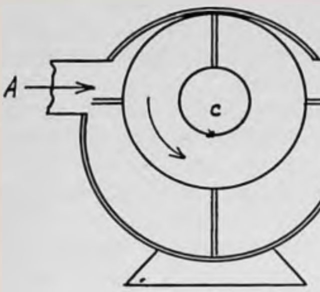


Fig. 1

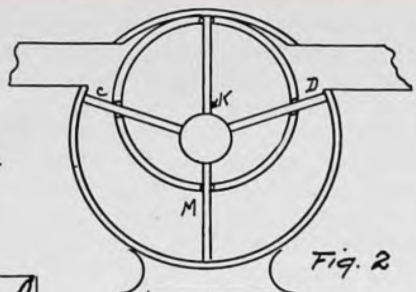


Fig. 2

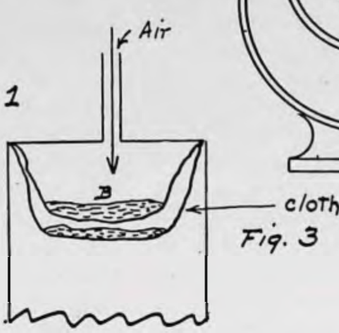


Fig. 3

Fig. 4

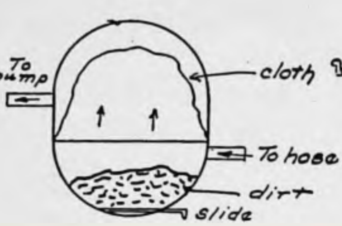
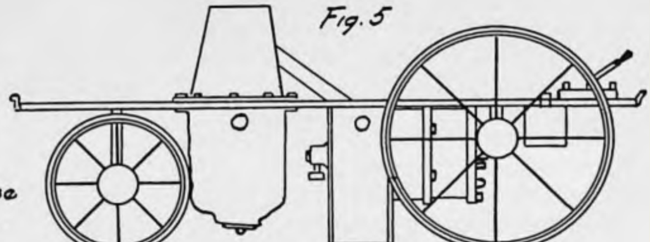


Fig. 5



larger volume of air in the fan machine of course displaces the most dust in the least time. In practical operations, however, the dust would be inside the carpet, and the weak suction of the fan machine would not gather as much dust as the somewhat smaller volume of the pump machine with its greater suction power.

Piston pumps are all right for stationary purposes or with vacuum wagons but heavy weight and slow speed are essential for proper operation.

Diaphragm pumps are a modification of piston pumps, the idea being to increase the speed and decrease weight. This is the most common type of pump and, in some cases, the cheapest. When the speed of a single pump is increased, the stroke must necessarily be decreased in order to reduce vibration. This shortness of stroke greatly increases the proportion of useless air in the ends of cylinder and in valves resulting in a loss of vacuum. To reduce friction, which would be on a stuffing box, and to get rid of cross-heads and guides, many concerns use single-acting pumps, having the cranks connected directly to armature shaft at one end and leather diaphragm at the other. This, of course, eliminates many parts which would be required in a double-acting pump, but it also cuts the volume of air in two and a fairly good balance is lost.

The last class, rotary pumps, are, when properly made, the very simplest and best. Their advantages are, a perfect balance, high efficiency (no lost motion of air), durability and compactness. The principle is shown in Fig. 1. Air enters at *A* and is caught and forced around to *B* by the impellers attached to *C*. Thus the air moves continuously in one direction and no lost motion is possible. This type of rotary pump is the most common, but a better type is shown in Fig. 2. Here, there are four blades also, but the blades are radii of the larger circumference, and are fastened on a pivot in the center and pass through equally-spaced slots in the smaller cylinder.

There is one make of this type of pump using only two blades. Two blades would necessitate a complicated mechanism inside the smaller cylinder to hold the pivot of the blades in the axis of the larger cylinder. If four blades were used the pivot would hold itself.

Most dust separators are inverted from what they should be. The dust collected in the cloth bags soon covers up the pores of the cloth and interferes with free passage of air. Fig. 3 is a typical form; air enters at the top and passes down through one or several cloth bags hung from the top ring, each time leaving some of its dust behind in the bags. Soon, enough dust collects as, at *B*, Fig. 3, to interfere with the air current. A better form than Fig. 3 is shown in Fig. 4. Here, the air passes up and the dust which would otherwise collect on the cloth, drops down into a receptacle and leaves the cloth free to filter more dust. This receptacle can well be made of glass, as it will then also serve as an indicator to show when dust is passing.

As 60 cycle alternating current is the standard, an induction motor of that type is best. It contains no commutators, brushes, nor moving wire, in fact, nothing to give trouble. Many starting devices in a motor waste much of the current when running, or else take up much room with the extra coils; therefore, the best is the simplest: a straight single-phase motor directly connected with the rotary pump.

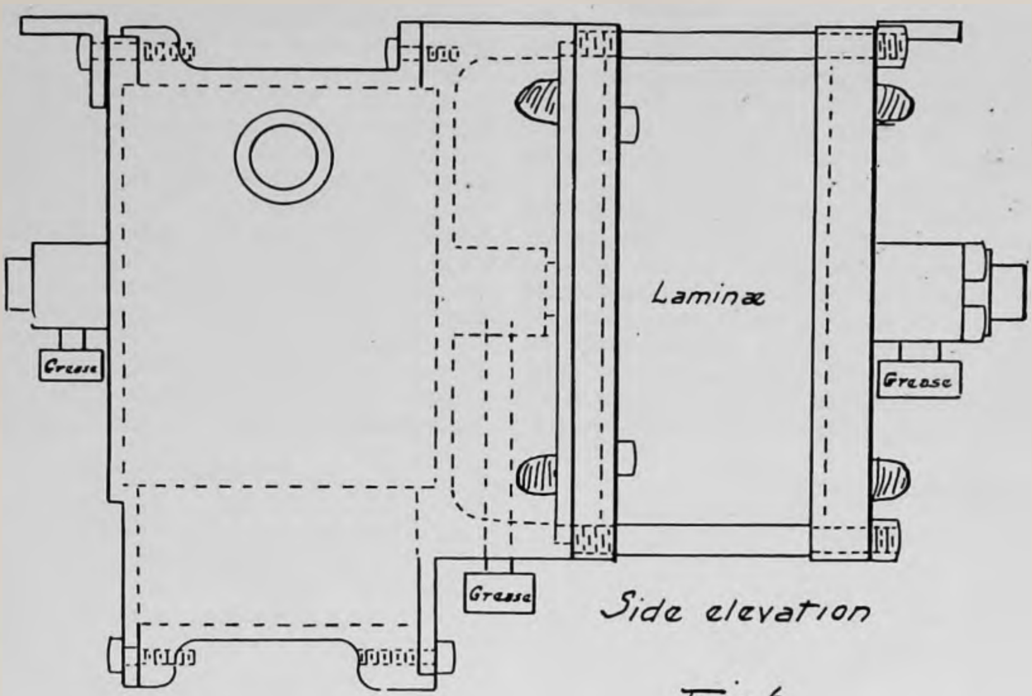
Fig. 5 is a general view of the outfit I will describe. Fig. 6 is the external appearance of pump and motor combined, with as much internal section as is necessary to understand it. The rotor shaft of the motor is joined directly with the pump, only three bearings being used, one at each end and one in the middle.

A description of the machine work may seem tedious; but the order of constructing the parts is really necessary, as each piece depends upon the one preceding.

All the work on this outfit can be done on an 11 in. lathe, except the slots in the hinges, which must be milled to be made accurately.

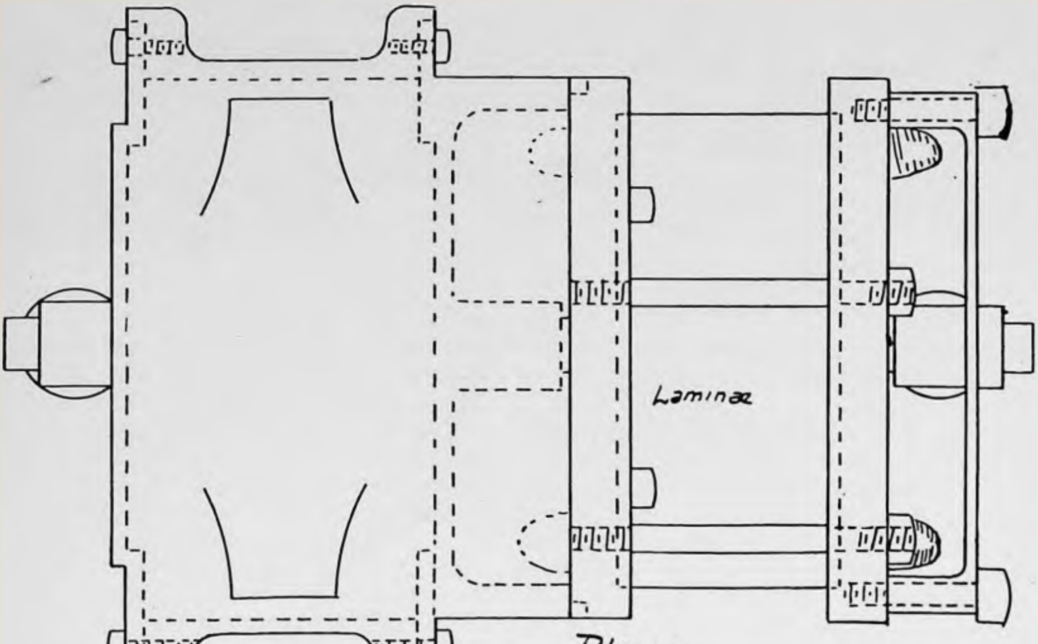
PART I.—MACHINE WORK

Figs. 7 to 20 are drawings of the parts; these are finished sizes, so about ⅛ in. extra should be allowed in patterns for castings, on account of shrinkage and



Side elevation

Fig. 6



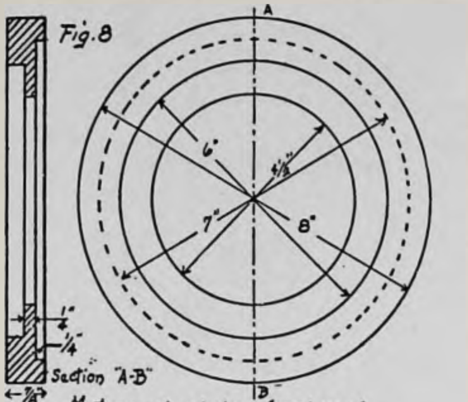
Plan

turning up. For the pump cylinders cores will be required. An easy way to make a core box is to turn up a piece of wood the same dimensions as the sand core is to be later; that is, the inside dimensions of the cylinder with core prints added. Embed this wood half way in a box filled with plaster of Paris, and scrape off superfluous plaster even with box. Just before the plaster hardens remove the wood and an accurate imprint will be left. It is much easier to make accurately the plaster core box formed in this way than to gouge out a piece of wood.

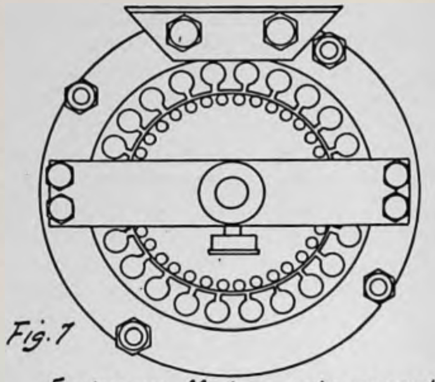
The core prints for these boxes should be about 1 in. long with a slight taper. The "cast iron parts" might be cast in aluminum; they would be much easier to turn on a small lathe, and about ¾ of the weight would be removed. In this case, the bronze bushings for shaft might be omitted as aluminum in itself is a good bearing metal. The impellers

⅜ in. holes in the other, clamped with hexagon nuts, ⅜ in. 16 thread.

At first, all eight holes are tapped, to afford a hold on the face plate in turning. Take care to have the inside circle of rods the exact diameter of laminations. After fastening one plate on the face plate, take a cut off from the front. Then turn it over and finish both edges and the inside face (the one to rest against the laminations), taking care to turn the edges concentric with the circle of rod centers. This is necessary to have the rods fit tightly to the laminations, and so prevent their moving. Drill the holes in shaft support



Motor end plate (cast iron)



End view Motor-wire removed

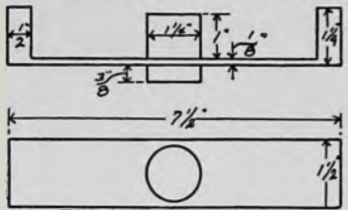


Fig. 9 Motor shaft support (cast iron)

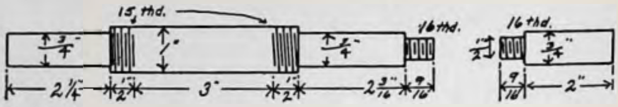


Fig. 10 Shaft (steel)

might be cast in brass, but bearing bronze wears better on account of its hardness.

First, cut out from 26 gauge sheet iron, enough of 7 in. and 4¾ in. circles to form a pile of each 3 in. high. This is best done by first cutting the iron into 7 in. and 4¾ in. squares on the square shears at a tinshop, and then running them through circle shears. About 40 lbs. of iron will be required, costing about $1.75. These are for the stator and rotor laminations. To hold the stator laminations together, four ⅜ in. steel rods are used, threaded into the middle end plate (the one toward the pump) and passing through

casting and angle irons as shown in motor drawings. Next drill the eight ¼ in. holes in the middle end plate (on a 7½ in. diameter line of centers) and drill and tap the 5/16 in. holes in other plate for shaft support and angle irons.

Turn up the three bronze bushings for bearings, 1½ in. long, 1 in. outside diameter and ¾ in. inside. Reaming would be a good way to finish the inside; it leaves a smooth and accurate hole. The outside might be turned on reamer as a mandril by putting a pin through at end of bushing engaging in one of the flutes. Drill out the rod threads in the outside plate, and screw the four rods into the middle plate.

Pile up the laminations between the rods, separated from one another by tissue paper, and coat each with shellac. Make the pile as straight and perpendicular as possible. When the pile is complete, put the other end plate on and screw down the nuts as tightly as practicable.

Then mount the whole on the face-plate by means of projecting ends of the rods on the threaded plate end. Bore out the armature tunnel, by cutting off each lamination, one by one, with a thin and sharp tool, acting more to part the metal than to remove any of it. If a blunt tool is used removing metal, the sheets are apt to rip and tear, making a hard job and much ragged work. It would be well, first, to cut the tunnel to about 4¼ in., afterwards boring it out to exactly 4½ in. with a high speed and keen tool. This is necessary to avoid turning the edges of the sheets together and forming a path for eddy currents. I have found that better results will be obtained in turning laminated iron if little or no side rake is left on tool. When this is done, mark the line of centers (5⅟₁₆ in. diameter) of stator holes and index this circle into twenty-four equal divisions. Then mark these divisions down the tunnel by moving the carriage on lathe longitudinally with a boring tool just scraping along. This will give a set of divisions on the opposite end which can be relied upon to be in line with those in front. Now, with the tail of lathe in a mark on one end, and the point of a ½ in. drill in its opposite, drill the holes through the laminations and the ¼ in. of cast iron which covers up the ends. This cast iron left, is only to protect the ends in boring and sawing the slots, and is to be chipped out later. It would be a good idea to use a high-speed drill in boring these and the rotor holes; much time would be saved and a cleaner hole made. Now chuck the motor frame on the inside of the armature tunnel, with the middle end plate out, and turn off a section ¼ in. x ¼ in. from the outside corner. Then turn the frame around on the chuck, screw the shaft support on and bore out the central hub to a good fit for its bronze bushing. Chuck the middle pump end plate on its motor ring and face off the exposed surface. Finish the hole into which the smaller pump cylinder is to set, to 6 in. diameter and ¼ in. deep. Then bore the central hub for its bronze bushing. Find the center of the outside edge of casting and from there as center, draw a circumference of 8¾ in. diameter. Divide this circumference with eight equidistant holes ¼ in. diameter. Fasten the plate, its face against the face-plate of lathe, and true it up until the 1 in. hole in hub is exactly central, then clean up the end and outside of ring, and the end of hub and exposed surface of plate. Turn out a section about ¼ x ¼ in., so the end of motor shall make a tight fit with the inside of ring. Then fit the motor into its groove and mark the eight holes when the angle iron is in its correct position. Now drill and tap the holes in plate for ¼ in. 20 thread; the metal may have to be chipped off around the mark in order to start the drill. Fasten the ring against the face-plate so bronze bushing is exactly 1 in. out of center, and turn off outside edge of the plate to exactly 9½ in. diameter. Chuck the other pump plate on its hub and face off the exposed surface (except hollow which is to be left until later). Drill the eight holes as in other plate, and fasten it against face-plate of lathe so the hub is as nearly 1 in. out of center as possible. Then turn off the outside edge to 9½ in. exactly.

Chuck the outside cylinder on its outside, and turn off one end and a small distance on the outside, to fit the plate tightly. Bore out the inside of cylinder to 8 in. exact. Use as stiff a tool as possible, making it in at least four cuts, the last one very fine. Then chuck the cylinder on its finished end and finish the other end. A good polish can be put on the inside of cylinder with very fine emery and oil. Place the two plates on the cylinder in their correct positions, and mark the holes in flanges. Have the hubs as near in line as possible. Drill the holes ¼ in. 20 thread. Screw the two plates on the cylinder; chuck the motor ring and bore the remaining hub for its bushing. Then bore and tap the air inlets in cylinder for 1 in. iron pipe.

Get a piece of 1⅛ in. steel shafting and cut off two pieces 9 in. and 2⁹⁄₁₀ in. long. Make good centers in both and turn

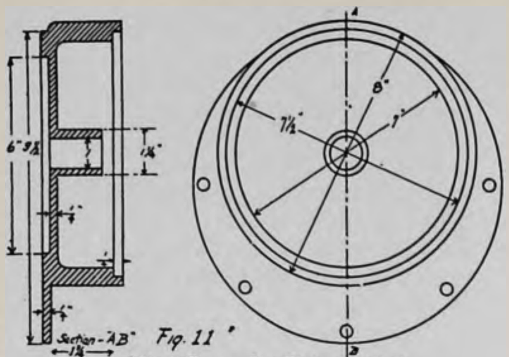


Fig. 11 Middle Pump End Plate (cast iron)

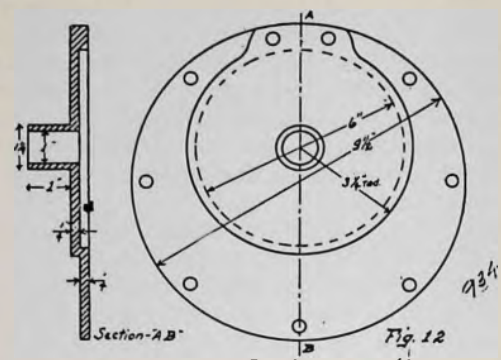


Fig. 12 Outside Pump End Plate (cast iron).

according to shaft drawing. Make the end section of shaft very smooth and a good fit in their bushings.

Clamp the rotor laminations, two plates of $\frac{1}{8}$ in. iron, two $\frac{1}{16}$ in. copper discs and about 150 sheets of tissue paper between two pieces of wood on the face-plate as near central as possible, and drill a 1 in. hole through the whole. The laminations must be clamped very tightly otherwise their edges are liable to be burred over in drilling. Then thread two hexagon nuts to fit the middle threads on the shaft, screw one on, put on the iron and copper plates, and then pile up the laminations in the same manner as the stator was piled before. Finally, put on the other plates and screw down the nut. Center the rotor in lathe and turn it down to $4\frac{15}{32}$ in. or $\frac{1}{64}$ in. clearance on each side of the rotor when placed in stator. Then turn the steel and discs down to $3\frac{1}{2}$ in. diameter. Turn a center line for holes $4\frac{1}{8}$ in. diameter and index it into 36 divisions; scratch across as before and drill the 36 $\frac{1}{4}$ in. holes clear through. Cut off 36 pieces $\frac{3}{16}$ in. copper rod $3\frac{1}{4}$ in. long. Also 36 pieces fiber tube $\frac{3}{16}$ in. inside, $\frac{1}{64}$ in. thick and 3 in. long. In the absence of fiber use paper or mica strips. Fit these into the holes with shellac, and rivet the ends of the rods over onto the copper plate. A center punch can be used to start the ends over, as otherwise the rods are apt to shorten up their whole length. Now turn down the hexagon nuts to allow about $\frac{1}{16}$ in. end play, when the ends of the rotor are even with the ends of the stator, and when the shoulder on the shaft is flush with the surface of the hollow in the pump.

Chuck the inside pump cylinder on one end and face off the other. Then turn it around and face the remaining end, making cylinder $4\frac{3}{16}$ in. long exact. Chuck the caps for the small cylinder on their outside edges and face off the surface. Bore and thread the hub to fit the ends of the shaft. Screw the ends on the short shaft as a mandril, and face off the inside surface and end of cap, making caps $\frac{5}{32}$ in. thick. Drill the eight $\frac{3}{16}$ in. holes from the outside surface of the cap on a $5\frac{1}{2}$ in. diameter line of centers. Rest the small cylinder against each cap as central as possible, and mark the holes with a center punch. Drill and tap the holes in cylinder for $\frac{3}{16}$ in. 24 thread. Then put caps on the cylinder with flush head screws, and mark and drill the four $\frac{3}{8}$ in. holes (on the line of screw centers) through cylinder, taking care to have them as near the center of the bosses on the inside of the cylinder as possible. Then ream the holes with the $\frac{25}{64}$ in. reamer. Now screw the shafts in the cylinder, center in lathe, and turn cylinder, ends and all, to 6 in. diameter exactly. Finish up very smoothly so that it will make a sliding fit with the hollow of the middle pump plate. Turn the hollow of the outside pump plate on the short shaft as mandril until it is $\frac{1}{4}$ in. deep and the diameter is a sliding fit with inside cylinder. Unscrew the end caps from the cylinder, saw down the middle of each reamed hole until the cylinder is in four parts. Then file corners of each hole back to an angle of about 30 degrees as shown in the drawing of the impeller packing. Screw impeller castings on the face-plate from the free corners and face off one side after another until the impellers are all 5/32 in. thick exact. File up the edge of lug on each. Turn up impeller pivot from steel to the sizes given in drawing. Drill 3/8 in. holes in the hinges and ream to 25/64 in., running the reamer through both holes at once. Mount the hinges in milling centers and mill the slots with a 5/32 in. cutter. Drill and tap three 3/16 in. 24 thread holes through each blade and its hinge. Then mount the four blades on their pivot, wedge carefully with wood and turn off the edges to an exact fit with the inside of the outside cylinder. Take especial care with the ends; make the edges very smooth. A good way to make the half round pieces for packing is to solder two strips, one on each side of a piece of 5/32 in. brass, and then turn the whole down to a fit with the reamed hole. On heating, the pieces will fall apart and the solder can be wiped off with a rag. Drill and tap the two outside hubs for 1/8 in. pipe, for the grease cups. The middle cup is connected by a small pipe with driven joints.

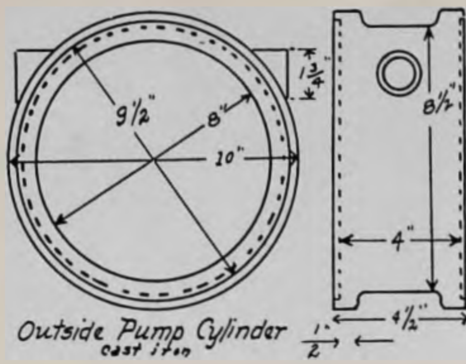
Arrange guides, and saw the slots in the stator. Use four saws together, cutting a slot 1/8 in. wide. This is not hard work as the slots are only 1/16 in. deep. Then chip away the cast iron remaining over the laminations. Saw the rotor slots by cutting through the metal remaining over the center of each rotor hole, using a single hack-saw.

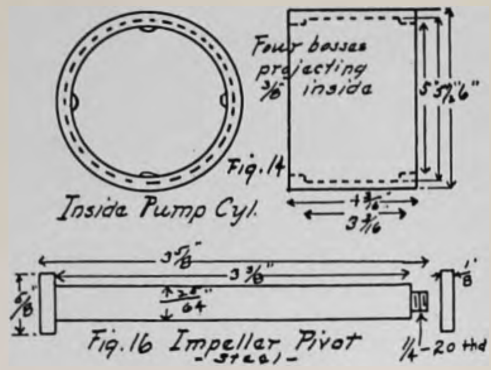
Part II.—Winding Motor

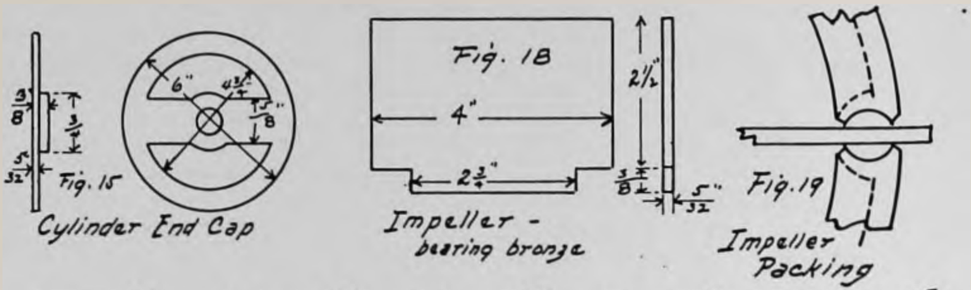
Cut out 24 pieces fiber 1/64 x 1 3/8 x 4 in. and 24 pieces 1/32 x 1/4 x 4 in. Curve the wide pieces and slip them into the stator holes. Make out of 3/8 in. wood a trapezoid with parallel sides 4 in. and 5 in., and the other two sides equal. Make the distance between the parallel sides 2 1/4 in. Make sides for this former extending out about 3/8 in. on each edge and hold together with two bolts. Wind 24 coils of No. 22 d.c.c. wire on this form, 40 turns per coil, leaving about 3 in. extra wire for connections. About 3 1/2 lbs. wire will be required. Tape up each coil with cotton tape about 1/2 in. wide, bringing out connections at one end of long side. Wind very tightly and stick the end down with shellac. Flatten the parallel sides with a pair of pliers and insert coils in slots, taking care not to scratch tape in doing so. Begin by placing one coil, connections toward open end of motor, with its short side in one slot. Place another on over the first, in the next slot, continuing this until all the coils are in. When the fourth coil is in place, the long end of the fourth coil can be inserted in the top of the slot occupied by the short end of the first coil. Continue in this way until all coils are in their final places, all connections are on the same end (the open end of motor), and the coils look symmetrical. Then slip in the narrow fiber strips over the coils, thus locking them in place. Divide the connections into eight groups, thus: eight groups, three sets of two wires in each. Solder up the connections and cover with tape. Connect the coils in each group so the current goes in the same direction, but reverse the direction between every two adjacent groups. On the terminals of each group solder two foot lengths of No. 18 stranded wire. Bunch the leads together and fasten with a small strap on top of motor. Then pour shellac down between the coils and set aside to dry. Proper connections are shown in Fig. 20.

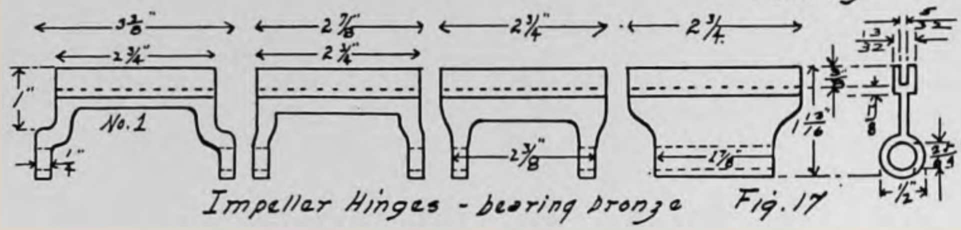
Part III.—Dust Separator

The dust separator is made in two parts, screwed together in the middle. Fig. 21 is a general view of the separator. No dimensions can be given as they depend on the size of the glass bottle. This bottle should be at least 8 in. in diameter, and with a mouth at least 3 in. in diameter, either ground glass or snap cover with rubber packing. A short bottle is best, as it would not be so apt to get smashed, and a better space would be left underneath for pan to empty the dust into. Drill a small hole in the center of the bottom of bottle using sulphuric acid on drill. Use this hole as a pivot and cut a circle out of the bottom, leaving a flange 1/2 in. wide around the edge. A very good cutter for this purpose can be made of a washer cutter. Take out the two cutters and make a single one with a clamp on the end to hold a small sharp carborundum crystal. The glass can be cut clear through in a very short time with this. It is necessary to cut the glass clear









through, otherwise it will be liable to crack.

Drill four 3/16 in. holes in the flange and a 1⅜ in. hole in the side of the bottle, 1½ in. from the flange end of bottle. This can be done with the crystal cutter also. Make the top half of the separator of galvanized iron with a double seamed top, and flange on the outside of bottom edge. Solder up all rivets and seams, on the inside. Drill the 3/16 in. flange holes and a 1⅜ in. hole about 3 in. from the top on the opposite side from the hole in bottle when put together. Cut out a tin ring; outside diameter the same as the outside of flange on galvanized iron; inside 2½ in. less in diameter. Run this through a flanging machine at a tinshop until the cross section approximates to Fig. 22. Drill the flange holes to correspond to the others. Sew two cloth bags to fit over the flange on the tin ring; one of fine duck, the other of heavy Canton flannel, such as is used to cover brooms. Make the flannel one about 2 in. longer than the duck and with the fuzz on the inside.

Part IV.—Accessories

Purchase a 25 ft. length of ¾ in. vacuum hose with connections on the ends. This should not cost more than $4.50, but remember, a good hose is always the cheapest. Most foundries now have standard cores and patterns for vacuum floor tools. In the absence of these, patterns can be made, but, at any rate, get two tools, a 6 in. and 10 in., cast in aluminum. File up the bottoms and sides of tools and ream out the hole to the same taper as the hose connections. Get a 3 ft. piece of aluminum or steel pipe, ream out one end with the same reamer, and turn the other end down with the same taper.

Make a cart to hold the outfit, with a top-board about 12 in. wide and with three rubber-tired wheels. The wheels should be fastened high enough to have the dust separator about 4 in. off the floor.

The starting impedance for motor consists of 120 turns, No. 20 d.c.c. wire wound on a closed core 1 x 1 in., 55 turns on each leg. Build up the two legs first, with shellac, and then wind on the wire. Fig. 24 explains the construction of the core. Then put on the ends, clamp the ends of core between two pieces of hard wood and fix in a box underneath the top board of cart. Bring the connections up through the board to a double-throw switch. The binding-posts for current should be located under the top-board near the end.

PART V.—ASSEMBLING

Screw the motor and pump together, after smoothing up the internal parts of pump with a little very fine emery and much oil. The drive nut in pump on shaft should be pinned after screwing up. Fill the small cylinder about one quarter full of vaseline. Grease well all the wearing surfaces and fill the grease cups. The angle iron on pump can be fastened with two of the cap screws. Then fasten the pump and motor under the top-board with the angle irons and rubber pads to take up vibration. Connect up the motor as shown in Fig. 23.

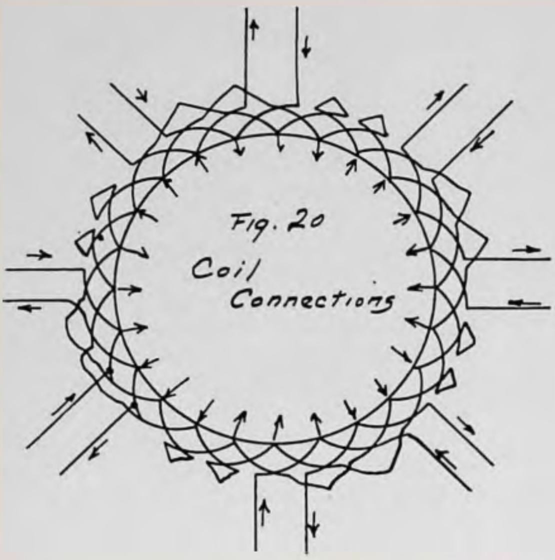


Fig. 20 Coil Connections

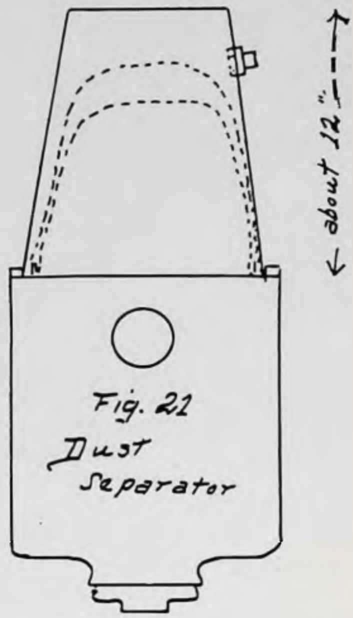
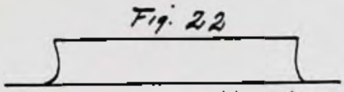
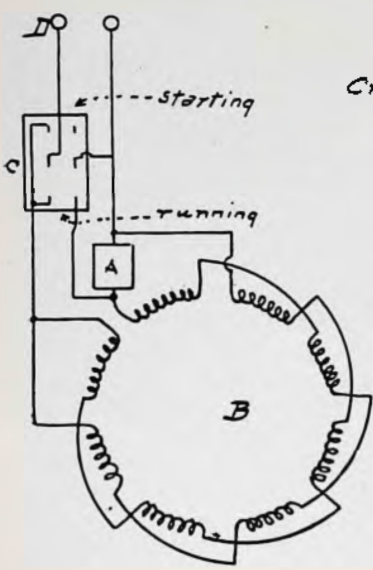


Fig. 21 Dust Separator

Fig. 22



Cross section of tin ring



A - Impedance
B - Motor
C - DPDT switch
D - Binding Posts

Fig. 23 Motor Connections

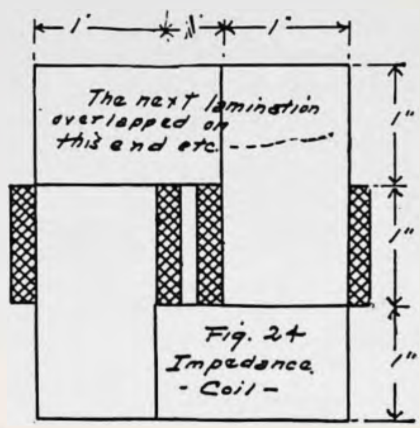


Fig. 24 Impedance - Coil -

Cut a hole in the top-board, a good fit for dust separator. Put the two bags on their ring, fasten each with a strong rubber band. Then put the two halves of separator together with 3/16 in. bolts, the bag ring and rubber packing between the two. The bolts should have leather heads against the glass. Connect the top half of separator up to the suction end of the pump, that is, the end which is the inlet when the shaft screws into the inside pump cap. If the shaft revolves in the opposite direction, the whole strain will come on the pin. Use 1 in. iron pipe and lock-nuts in the bottle connections. Screw a 4 in. piece of 1 in. iron pipe into the other pump opening, with its free end reamed for hose-coupling. Do the same with the other bottle opening, using lock-nuts. Thus the hose can be connected to either vacuum or compressed air. Put a pipe strap around this pipe with a piece of rubber under it, to take the strain off the glass. Use a 25 ft. length of flexible cord and push-plug to complete the outfit. A lamp-socket plug can not be used with this motor as the 5 amperes needed exceeds the fire limit. This disadvantage of not being able to attach to a lamp socket is nothing, as baseboard plugs located in two opposite ends of a house will suffice. Most people would not bother about unscrewing a lamp from a fixture anyway. The 6 in. and 10 in. tools can be used to clean almost everything except hardwood floors. In this case the tool must be raised from the floor by a set of brushes.

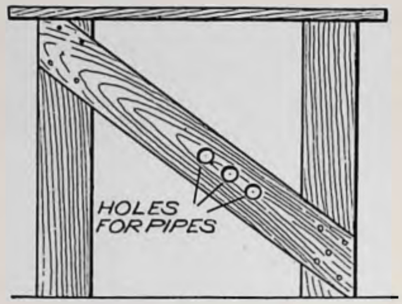
This outfit will be very durable, economical and convenient. It will displace at least 45 cu. ft. of air per minute, and produce at least 10 in. vacuum at the end of a 25 ft. hose. After about two years' use the pump plates will have to be taken off and set in a little with emery, to take up wear.

The upper cloth bag in separator should not require emptying more than four times a year when used about five hours a week. The dust can be emptied by simply pulling out one plug and dumping directly into a box, a much easier thing to do than dumping most cleaners.

In business building, advertising is a substitute for time.

Bending Pipe

I have been very successful in making bends of piping of 1 in. and smaller sizes in the following manner, says B. F. Hartley in *Practical Engineer*. With a brace and bit bore a hole about ½ in. larger in diameter than the pipe to be bent in a soft pine timber which is made



OUTFIT FOR BENDING PIPE

solid in the building, tank bracing or foundation, insert the pipe to the point at which the bend is desired and make the bend by pulling slowly to one side, moving the pipe in and out a little after each pull. It will be seen that the soft pine will give way to some extent and will not crush the pipe which, being cold, will not flatten at the outside of back of bend. The main point is, don't try to make the bend in one or two pulls.

The sketch shows all the outfit I have used to make bends of those sizes. The timber which has the holes bored for the pipes is part of the bracing in a tank platform and is 3 in. thick by 12 in. wide.

Dense vegetable growth of the Nile, which is a continual nuisance to river navigation, may become an Egyptian asset, if the tests made of it as fuel in the form of briquets are as successful as claimed. The vegetable growth, known as sudd, is to be dried, disintegrated and compressed into briquets by machinery. The resulting fuel is claimed to be suitable for use in boilers, in which it is expected to give an evaporation of about 4.75 lb. of water per pound of briquets.—*Popular Mechanics.*

There is quite a difference between earning money, making money, and getting money. The first may be called honesty, the second speculation, and the third robbery.—*System.*

WIRE AND WIRE ROPE ON AEROPLANES

(Illustrations from the author's drawings)

H. A. WHITNEY

Since the Wright brothers made their first successful flights with a power-driven aeroplane, in December, 1903, aviation as a scientific study, as a sport, and as an industry, has made remarkable progress.

In the future commercial and social activities of the world, air craft will play an important part, as a practical means of conveyance, for carrying mail or express matter at high speed, in the exploration of remote and inaccessible places of the world, as a popular sport and especially as an effective implement of war.

The widespread interest in flying machines, created and fostered by the spectacular and thrilling feats of daring aviators, is fast being crystalized in the minds of thousands of adventurous persons into an enthusiastic desire to taste the delights of flying. The aero training schools are besieged by applicants eager to learn the art of airmanship, while the popularity of aerial navigation is being rapidly advanced in many localities by active aero clubs. Every prominent college now has an aeronautic society, conducting scientific experiments, the results of which will undoubtedly be of great value to engineers and designers of aeroplanes.

The solving of the problem of automatic balancing of aeroplanes, now receiving the serious attention of the ablest minds, will increase tremendously the safety and popularity of flying machines. So rapidly are improvements in the construction of aeroplanes being made that it is safe to predict that air travel eventually will be no more hazardous than travel by steamship, railroad or automobile. For the present, however, the aviator's safety and success depend, not only upon the possession of a well constructed aeroplane, but upon his skill, courage, persistence and knowledge of what his machine is capable of doing.

The remarkable yet fateful flight of Chavez over the Alps lends particular emphasis to this last statement. According to his own account, Chavez drove his monoplane through the baffling gusts of wind to a height of over 8,000 ft.; then began the long free engine glide or series of volplanes. On the final steep swoop, the aeroplane attained terrific speed. At the moment when it became necessary to straighten up the machine, and, from pointing earthwards, bring it to an even keel, an extra strain was thrown upon the supporting wings and stay wires; the latter broke, the wings collapsed, and the machine and aviator were dashed to the ground. Chavez died from his injuries a few days later.

By similar breakdowns, due to the too sudden checking of rapid descents, several notable aviators lost their lives during the past year. Obviously, the designers and builders of aeroplanes are seeking the most dependable, light-weight engines, propellers of highest efficiency, the strongest and toughest wood, fabric metal fittings, wire stays, wire rudder cord, and aileron or wing warping cord.

IMPORTANCE OF STAYS AND FASTENINGS

It must be apparent to persons at all familiar with aeroplane construction, that there is no more important part of an aircraft than the steel stays and fastenings that bind the otherwise fragile structure together, and give it the requisite rigidity and strength. As the trite saying that "a chain is no stronger than its weakest link" is particularly applicable to the assembled parts of an aeroplane, it is imperative that great care be exercised in selecting the quality and sizes of eye-bolts, turn-buckles, stay wires or stay strand that will afford as nearly as possible an equal and sufficient strength.

Let us first consider the merits of material available for stays. The American Steel & Wire Company were the first manufacturers to produce special wire, wire strand and wire cord to meet the exacting requirements of aeroplane constructors. With the most modern steel furnaces and the most skillful steel makers in the world, they are able to supply wire, wire strand, or wire rope possessing the best qualities for unusual conditions of use.

It is generally known that in no other form than wire can as great strength be obtained in the same area and weight. With this fact in mind, inexperienced builders of aeroplanes sometimes buy the strongest stay wire that can be produced, only to learn that such high carbon steel wire is necessarily hard and stiff and consequently difficult to fasten, lacks toughness and will not withstand, without crystalizing, the vibration caused by the powerful engines.

DESIRABLE QUALITIES OF STAYS

Experience has demonstrated that the desirable qualities of stays are good strength combined with toughness, to withstand bending and vibration; elasticity, to resist sudden strains; and protection against rust. Coating wire with tin or spelter,—the latter accomplished by the processs known as galvanizing,—is the most common and effective way of preventing the deterioration of steel from atmospheric action. Tinned wire, although somewhat stronger than the same wire galvanized, does not resist corrosion nearly as long as the latter.

STAY WIRE

There is on the market a special tinned or galvanized aeroplane stay wire that has all the strength that it is possible to secure without sacrificing toughness and elasticity. In the rigging of a well-stayed biplane, approximately 700 ft. of wire is used. The sizes generally recommended are .070, .075, .080, and .085 in. diameter, and for the main stays that sustain the greatest strains, .090 and .095 in. diameter. If stay wires of ample size and strength are stretched taut when rigged on an aeroplane, turnbuckles are not absolutely necessary, although each stay is usually equipped with a turnbuckle or wire tightener.

STAY STRAND

For reliable strength, light weight, flexibility, toughness and elasticity, the American galvanized high strength aeroplane strand, composed of 19 galvanized wires, is unrivaled. The merits of this stay strand may be briefly summed up as follows:

The strength is distributed among 19 small wires twisted into a concentric strand. The core of 7 wires, comprising more than one-third of the total strength of the strand, is protected from injury by the outer layer of 12 wires. The efficient strength of a single steel stay wire may be tremendously reduced by a slight nick or abrasion of its surface, at which point it is then liable to snap under a sudden but not necessarily severe strain. The same accidental cutting or nicking of the stay strand probably would not affect more than two or three of the outside wires, the strength of the remaining wires being unimpaired.

A strand of small wires offers greater and more reliable strength than a solid wire of the same weight.

Being more flexible than a solid wire of the same strength the strand is more easily fastened to eye-bolts.

Stay strand does not deteriorate from vibration as rapidly as a solid wire.

The wires are laid up spirally, giving the strand elasticity to withstand the sudden heavy strains to which the machine and stays are subjected.

The construction, weight and minimum breaking strength of American galvanized high strength aeroplane strand are here published.

Diameter	Number of Wires	Weight per 1,000 ft.	Minimum breaking strength
1/32 in.	7	2.3 lbs.	125 lbs.
1/16 in.	19	8.9 lbs.	500 lbs.
3/32 in.	19	17.0 lbs.	1,100 lbs.
1/8 in.	19	33.0 lbs.	2,000 lbs.

The strand is exact size and the breaking strength may be absolutely relied upon.

This stay strand is put up in coils of 50, 100, 500 and 1,000 ft. each. For main stays, the 3/32 in. diameter strand is most commonly used, while the 1/16 and 1/32 in. diameter strand is employed in staying the elevating planes, the rudder frame, etc. It is best to place a turnbuckle on each stay strand in order to adjust and maintain a uniform tension, thus equalizing the stress on all parts of the machine.

FITTINGS AND FASTENINGS

Although there is little available information on the subject, it ought to be generally understood that the method of fastening the wire or strand should be such as to equal the strength of the stay; yet the attaching of stay wire or stay

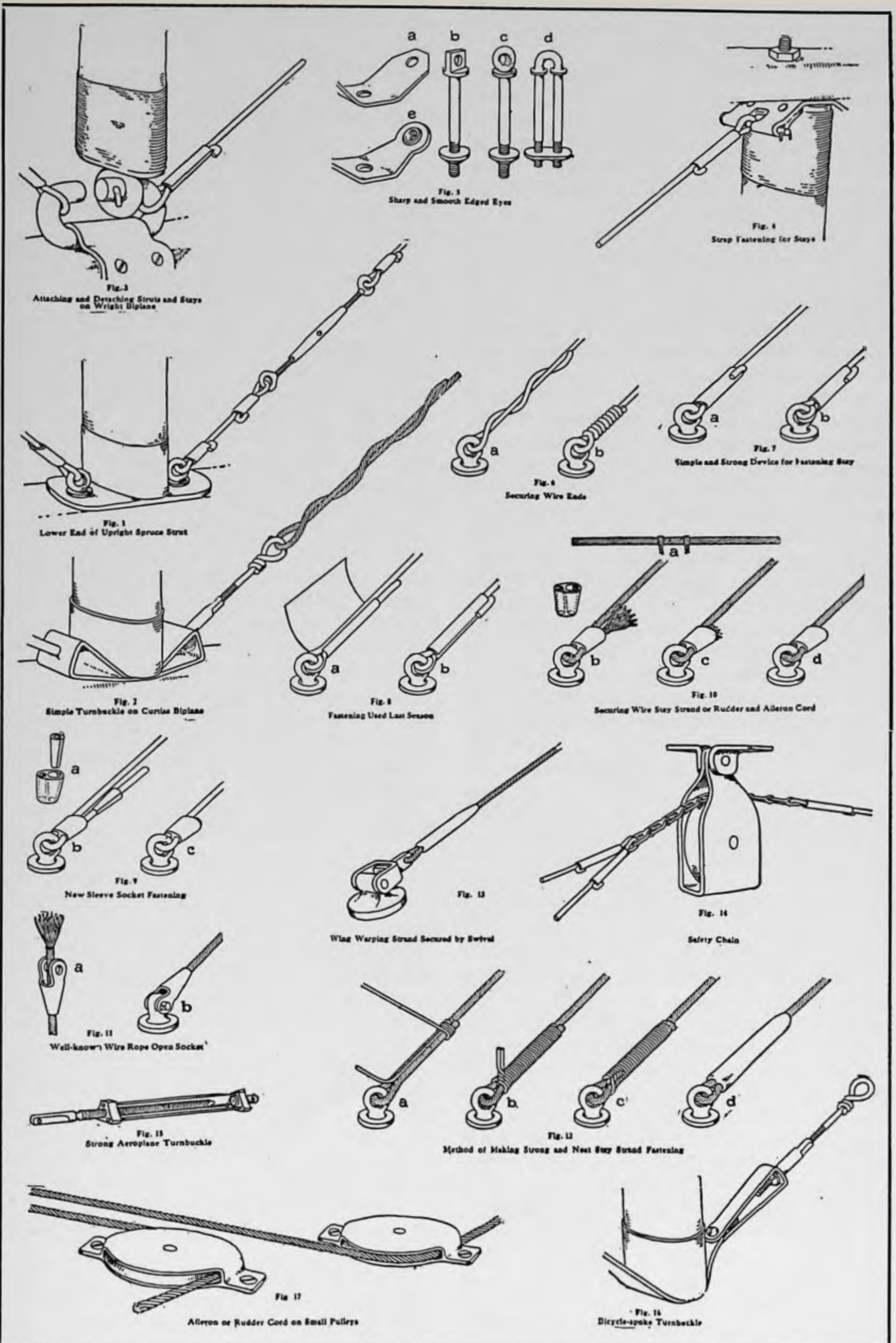


Fig. 3
Attaching and Detaching Struts and Stays on Wright Biplane

Fig. 5
Sharp and Smooth Edged Eyes

Fig. 4
Strap Fastening for Stays

Fig. 1
Lower End of Upright Spruce Strut

Fig. 6
Securing Wire Ends

Fig. 7
Simple and Strong Device for Fastening Stay

Fig. 2
Simple Turnbuckle on Curtiss Biplane

Fig. 8
Fastening Used Last Season

Fig. 10
Securing Wire Stay Strand or Rudder and Aileron Cord

Fig. 9
New Sleeve Socket Fastening

Fig. 13
Wing Warping Strand Secured by Swivel

Fig. 14
Safety Chain

Fig. 11
Well-known Wire Rope Open Socket

Fig. 15
Strong Aeroplane Turnbuckle

Fig. 12
Method of Making Strong and Neat Stay Strand Fastening

Fig. 17
Aileron or Rudder Cord on Small Pulleys

Fig. 16
Bicycle-spoke Turnbuckle

strand to eye-bolts, eye-plates, and turnbuckles is sometimes accomplished in crude and inefficient ways.

For the benefit of aeroplane constructors, we show some of the present aeroplane stay fastenings and special fittings, together with illustrations of improved methods of securing wire, strand and cord which by tests have been found very efficient.

Fig. 1 illustrates the lower end of an upright spruce strut, a strut socket and eye-bolts, and a common method of attaching a wire stay. This brass sleeve fastening and the bronze pipe turnbuckle are used on the Farman biplanes and Bleriot monoplanes.

In Fig. 2 a peculiar yet light and simple turnbuckle is employed on the Curtiss biplane, this turnbuckle being nothing more than the rim end of a bicycle spoke inserted in a brass or steel strap, the spoke itself being cut off and twisted into an eye. In fact, this is known as a bicycle-spoke turnbuckle. On the latest improved bicycle-spoke turnbuckle, made by the Standard Co., the metal strip that goes under the strut is of steel. On the Curtiss machine, the strand is passed through the buckle eye, three or four long wraps are made about itself, and soft solder run into the grooves where the two parts touch. When it is desired to take up more stretch than the short length of the threaded portion of turnbuckle will allow, the long soldered wraps are readily untwisted, the turnbuckle lengthened, and the stay strand drawn taut and refastened. If the soldering is carefully done, this makes a satisfactory fastening.

Fig. 3 illustrates the convenient method of attaching or detaching the struts and aeroplane stay wires on the Wright biplane. This and other ingenious appliances are covered by patents owned or controlled by the Wright company. The stay wires are of good size and consequently have sufficient strength to withstand heavy stresses without appreciable elongation, thus making turnbuckles unnecessary. The loop in the end of each stay is secured by wrapping a strip of thin sheet metal around the two wires, the flat strip being soldered upon itself. The short end of the wire is then bent backward forming a hook over the metal sleeve. Note that the end of the spruce strut is bound with wire to prevent splitting. This wire seizing is stronger and lighter than a metal ferrule.

In Fig. 4, the strong brass or steel strap fastening for stays here shown makes it possible to remove the stay by cutting off the soft iron wire in the end of the steel pin and drawing the pin. This pin is simply a steel wire nail with a small hole drilled in the end.

In Fig. 5, wire or wire strand should not be bent around fittings having sharp edges that might cut or nick the wire and thus render it more liable to break under strain. For this reason, the thin brass or steel plate with a hole through it (*a*) and the steel eye-bolt with sharp edges (*b*) are objectionable. The bolts with smooth rounded eyes or loops (*c*) and (*d*) and the steel plate with a countersunk rivet or eyelet (*e*), will not injure wire nor strand.

In Fig. 6, the most natural and common method of securing the end of a wire, is here illustrated. There is a great difference, however, between the "holding" qualities of the long twist (*a*) and the close wind (*b*); the former slips and eventually draws out, while the latter, especially if soldered, is a very secure fastening for the small wire stays on elevating planes and rudder frames. There are better ways of attaching the larger main stays.

Fig. 7 shows one of the simplest, lightest and strongest devices for fastening a stay. The wire may be put through the eye once (*a*), but for greater security, a double wrap should be made in the eye-bolt (*b*). A steel tube is better than a brass sleeve, for the reason that the hooked end of a stay wire, when bent over the thin edge of the steel tube shows less tendency to straighten and pull out than when turned over the thicker and softer edge of the brass sleeve. These seamless steel ferrules, about 1 in. in length, have rounded edges to prevent cutting the wire. The round steel ferrule, when slightly flattened by pliers to an oval shape, should be just large enough to receive the two parts of the stay wire in order to obtain the best results.

Fig. 8 shows a strong fastening, quickly made, and was used on several well-known aeroplanes last season. The end of the wire, after passing once or twice through the eye-bolt, is bound back upon the main wire by wrapping the two parts with a thin metal strip about 2 in. in width. The wire is bound tightly by the metal strip which is then soldered upon itself and the projecting end of the wire bent into a hook as shown.

Fig. 9 shows a new sleeve socket fastening (*a*) for stay wire that is quickly and securely applied by passing the wire through the socket and eye-bolt as shown (*b*). The split cone sleeve is then slipped over the end of the wire, and with a short length of steel tubing and a hammer, the sleeve is driven into the socket bowl, the end of the wire cut off, and swaged over the head of the split sleeve by a few light taps of the hammer (*c*). The ends of the holes in the socket are rounded or beveled to prevent cutting the wire. This sleeve socket fastening should equal the strength of any stay wire.

Fig. 10, for securing stay strand or rudder and aileron cord, the socket shown in Fig. 9 (*a*) may be used, but without the split cone sleeve. Before cutting wire strand it is well to bind it temporarily with soft wire either side of the point where it is to be cut, in order to prevent the strand wires untwisting (*a*). After dipping the ends of the strand or cord in molten tin or solder the binding wire may be removed. The soldered end of the wire strand is then readily inserted in the socket. Two or three wraps of very fine tough wires are made about the strand or cord 1 in. from the end and the wires untwisted, as shown at (*b*). By pinching the soldered end of the strand with pliers, the wires are easily separated and untwisted. The loose ends of the wires are then cleaned with benzine and coated with soldering paste, which is best applied with a brush. The soldering paste known as "Nokorode," is very satisfactory for this purpose. The end of the strand is then drawn back into the bowl of the socket as at (*c*) and molten spelter is poured into the socket about the wires. Any projecting ends of wires are cut off and the fastening is complete (*d*).

In Fig. 11 the well-known wire rope open socket of a small light pattern is here shown fastened to a stay strand. To attach this socket, the soldered end of the stay strand is passed through the socket, two or three wraps of fine tough wire are made about the strand as illustrated at (*a*). The wires are then untwisted, cleaned with benzine and doped with "Nokorode" soldering paste. The strand is drawn back into the bowl of the socket until the ends of the wires are flush with the large end of the socket bowl. Molten spelter is then poured into the socket and, adhering to the wires, forms a solid mass of spelter and wire which cannot be pulled through the socket (*b*). By the use of open sockets, stays may be fitted complete of the proper length and readily attached or detached as occasion requires.

The illustrations in Fig. 12 explain the method of making a very strong and neat stay strand fastening. The soldered end of the strand after passing through the eye is temporarily tied to the main part with string or wire if necessary. Tough annealed iron wire or soft brass wire used for seizing, is first laid into the groove between the two parts of strand. About 3 in. from the eye, the seizing wire is given a right angle bend and the wrapping begun (*a*); the ends of the seizing wire are twisted together (*b*) and laid against the seizing (*c*). The wires in the short projecting end of strand are next loosened or opened by pinching with pliers (*c*). This is done in order that the solder may adhere to the wires and form a knob that cannot pull out of the seizing. The entire seized fastening is then cleaned with benzine, coated with soldering paste, and heavily soldered (*d*).

If the surface of tinned or galvanized stay wire or stay strand has been scratched in securing it to eye-bolts, rust spots will soon appear, especially as the moisture settling on the stay runs down and collects on the fastening itself. It is, therefore, a wise precaution to paint all stay fastenings with black asphaltum paint or turpentine japan.

Fig. 13. On Santos Dumont's diminutive monoplane, the wing-warping strand is secured to the wings by the swivel fastening here illustrated. There is no movement of the strand at the loop, which would tend to abrade the fine wires of the strand, because the swivel allows the strand to pull directly

from the eye regardless of the angle of the wing.

The Wright biplane is equipped with American tinned aeroplane wire, not only for stays, but for the wing-warping and the rudder lines. Where a turn is made over a sheave with a wing-warping or rudder line, a short length of flat link or safety chain is inserted at the pulley as shown in Fig. 14.

In Fig. 15 the strongest aeroplane turnbuckle for its weight yet devised for use with wire, is here illustrated. The heads are of chrome steel connected by three high carbon steel piano wires. The threaded screw is also of piano wire. A turnbuckle of this pattern, size No. 7, having a take-up of 2½ in., weighs ½ oz. and will sustain a stress of more than 600 lbs. Owing to its peculiar construction, it is quite expensive.

Fig. 16. The bicycle spoke turnbuckle, fitted with a steel strap (not brass) that may be bolted to the steel strut plate, is probably the most generally approved combination stay fastening and tightener. The common turnbuckle (Fig. 1) inserted between the terminals of the stay, requires four separate fastenings of the wire or strand in each stay, whereas by the use of the bicycle spoke turnbuckle, placed at the lower end of a stay, only two fastenings are necessary,—a considerable saving in labor and expense in the rigging of a biplane with more than 100 stays. The tendency of turnbuckles to loosen from constant vibration may be prevented by wrapping with electrician's rubber-lined friction tape.

Probably at no distant date, aeroplane supply catalogs will give not only the weight, but the guaranteed strength of all aeroplane appliances. Until this is done, the prudent constructor will adopt American galvanized high strength aeroplane strand and cord, and then by actual test, select turnbuckles and fastenings of equal strength.

CONTROL ROPE OR CORD

As is generally known, the lateral balancing of aeroplanes is accomplished either by warping the wings or by varying the angle of incidence of the ailerons, small hinged flaps on the outer rear edges of the main wings. The wing tips and the ailerons are connected by a small wire rope or wire cord, leading through suitable pulleys, to the operating levers or wheel, or to the shoulder fork that embraces the aviator's body. The wing-warping cords on the Santos Dumont monoplane are connected to a tube sewed into the back of the operator's coat, so that by the swaying of the aviator's body, the wings are bent and equilibrium maintained. From the control levers or wheel, wire cords also connect with the rudder, elevating planes, brake, and engine throttle. For all of these important control lines, the American Steel & Wire Company have designed and now offer a special wire cord known as American galvanized flexible steel aileron or rudder cord, the 3/32 in. diameter composed of 12 strands, of 3 wires each; the ⅛ in. diameter having 19 strands of 3 wires each. This cord combines great flexibility and strength with the minimum amount of stretch, and the strength being divided among many wires, it is a much safer control line than a single wire. The cord works freely over small pulleys in any direction (see Fig. 17), and avoids the necessity of introducing chains at the pulleys where a single wire is employed. Common galvanized sash cord of 6 strands of 7 wires each, and a cotton center, should never be used for control lines, because it lacks strength and stretches too much. American galvanized flexible steel aileron or rudder cord, which has met with the immediate approval of the ablest aeroplane constructors, and aviators, is made in two sizes:

Diameter	Weight per 1,000 ft.	Breaking Strength
3/32 in.	15.5 lbs.	725 lbs.
⅛ in.	24.5 lbs.	1,150 lbs.

In order to obtain the best wire or strand for stays and the most reliable cord for control lines, the buyer should order direct from our sales offices or supply houses known to handle our goods.

"Who can give a sentence using the word pendulum?" asked the teacher.

Little Rachel's hand shot up. The teacher nodded encouragingly.

"Lightning was invented by Penjulum Franklin."—*Everybody's.*

WHAT CONSTITUTES SUPERIORITY IN AN AIR-SHIP*

COMMANDANT PAUL RENARD

I

The question has been much discussed as to what type has the most noteworthy qualities among the numerous devices which are today carrying men through the air. Some are partisans of the aeroplane, others of the dirigible, and these two camps are always in rivalry, sometimes in open enmity, so that unanimity is far from prevailing.

In aviation there are monoplane and biplane enthusiasts, those who prefer aeroplanes without a tail, such as the Wright's machines,† or with a tail, like all the others. In aerostation, or ballooning, some contend for the flexible type like the "Ville de Paris," others for the semi-rigid type like the "Republique," and lastly, others who vaunt the merits of the rigid type, like the "Zeppelin."

How can anyone know where to stand in the face of all these opinions? From a technical point of view, excellent arguments can be found in favor of each of the present types of air-ships as well as for those which may be later devised; specialists can discuss these questions indefinitely. Although as far as I am concerned I have a well-established opinion on this point, it is not from the theoretical standpoint that I wish to express myself today, but without wishing to pass judgment it seems to me worth while to at least indicate the considerations on which such a judgment should be based. In a word I should like to determine here what, from a practical point of view, are the qualities which can be demanded in an air-ship, and from among these qualities to choose those which are of the greatest importance, and which as a consequence should preferably serve as a criterion in passing judgment on a structure of a new kind.

According to the point of view, very different sorts of performances, if I may use such an expression, may be expected of an air-ship. You may, for example, wish to rise as high as possible in the air, and the capacity for upward ascension in such a case is evidently a quality to be considered. It is not enough merely to rise, however, but it is also necessary to stay there. The period during which the air-ship shall remain suspended in the air without touching the ground, therefore, is also one of the elements of interest in the question.

Another phase of the question is that any engine of locomotion must be able to cover distances; the distance which separates the point of departure from the finishing point is therefore one of the essential characteristics of a voyage. In fact one might be tempted to say that the best air-ship is the one that can travel the greatest distance in a single flight before touching the earth.

Finally, it is not only necessary that a certain given distance shall be covered but it must take the shortest possible time to accomplish it. In other words, speed is the most highly valued quality at the present day. In all types of locomotion, whether by bicycle, automobile, railroad trains, steamboat, or motor boat it seems that the principal aim is speed, always speed, and still more speed. This search for acceleration in means of transportation is one of the characteristics of our epoch; and it is not to be wondered at, for, although all space is open to us, still our time is parsimoniously dealt out to us, and the best way we can use it is to carefully economize it by the use of the powerful mechanical means at our disposal.

Aerial navigation does not escape from this general law of locomotion. Speed is therefore one of the important elements in the measurement of the value of an air-ship. But a distinction must here be made, for there are two kinds of speed to be considered, termed absolute speed, and individual speed. The absolute, or effective, speed is the one commonly considered. It is the speed measured with regard to the ground over which the air-ship is passing. If a dirigible starts from Paris at 8 in the morning and at 11 o'clock is above Auxerre, the distance between the two cities being 150 km. as the crow flies, we would say that its absolute velocity had been on the average 50 km. an hour. This absolute speed is

* Reprinted from Annual Report of the Smithsonian Institution.
† The Wright Aeroplane is now provided with a tail, or rear horizontal rudder.

the one of practical interest. It is the plain fact, all modifying circumstances being removed from the calculation.

From the point of view of merit in a device, however, it is precisely these modifying circumstances that should be considered. The effective velocity results from the combination of two other velocities, namely, the individual velocity of the vehicle, which will be defined shortly, and the velocity of the wind.

Everyone knows what the velocity of the wind means. As for the individual velocity of an air-ship, its definition is very simple; it is the velocity which the air-ship could attain if there were no wind, or, again, it is the velocity in calm air, or, finally, its velocity in comparison with the ambient air, considering this to be at rest.

Of these two elements, the combination of which determines the absolute velocity, one, the individual velocity, depends on the construction of the air-ship; and the efforts of all aeronautic engineers are directed toward giving this as great a value as possible; the other element, the velocity of the wind, is entirely beyond us, and we must submit to it, whatever it is. But, according to the direction and the velocity of the wind, it is necessary to have very different individual velocities to obtain a determined effective velocity.

If, for example, on the day when our dirigible traveled from Paris to Auxerre in three hours, the wind had blown exactly in the desired direction with a velocity of 50 km. an hour, the wind alone would have been sufficient to accomplish the voyage in the time given without any intervention of the individual velocity. The aeronaut could have stopped his motor and thus would have made the journey at little cost. The effective speed would be the same as the velocity of the wind, the individual speed zero; the wind would have done all and the machine nothing.

If the wind, however, although blowing in the proper direction from Paris to Auxerre, had had a velocity of only 30 km. an hour, the aeronaut, if he were contented with allowing himself to be carried by the wind, would have taken five hours to make the journey instead of three. To attain the previous speed of 50 km. per hour he would have to add to the velocity of the wind the 20 km. lacking, and this difference would be nothing else but his individual speed. In such a case we should say that the velocity of the wind had been 30 km. an hour, the individual velocity 20 km., and the effective or absolute velocity 50 km. per hour. Instead of doing all the work as before, the wind had only done the greater part and the motor the rest.

If the velocity of the wind had been but 10 km. the motor this time would have had to add not 20 km. but 40. In this case, the motor would have deserved the principal credit for the voyage, and the wind would have furnished only a slight supplementary velocity.

Let us suppose now, that the air is absolutely calm, that is, the velocity of the wind is zero. The motor alone can be counted on here, and it is due to it that the speed of 50 km. an hour is attained. The effective velocity will be equal to the individual velocity, and the motor will have done all and the wind nothing.

Finally, if the wind, with a velocity of 30 km. an hour, is blowing not in such a direction as to be astern from Paris to Auxerre, but in the opposite direction, the motor will be required to furnish an individual speed of 80 km. an hour. The first 30 are used up merely in compensating for the unfavorable effects of the wind, the other 50 alone being effective. This time the motor has not only done everything, as in calm air, but it has done more, for in addition to the absolute velocity it has had to furnish a surplus of individual velocity to counterbalance the hindering effect of the wind.

In a word, in order to attain the same practical result as before, that is, an absolute velocity of 50 km. an hour, the motor should be capable of giving to the air-ship an individual velocity of 0, 20, 40, 50 or 80 km. an hour.

We have considered here only the simplest case—when the wind blows in the direction of the place to be reached or in exactly the opposite direction. This is almost never the case in practice, so that it becomes necessary in each case to determine what the individual velocity must be to attain a certain absolute speed. The problem is now a little more complicated, but the conclusions are the same, and the individual velocity is necessarily sometimes less, sometimes more, than the absolute velocity, and at times the two may even be equal. To sum up, all that may be said is that the wind can be either a help or a hindrance to the progress of air-ships, and in exceptional cases neither obstructs nor is favorable to their evolutions.

By those with a different point of view, it may finally be asked if there is not opportunity to measure the value of an air-ship by the amount of useful weight carried, in personnel or in material. The power of transporting is certainly one of the qualities sought for in certain vehicles.

All the qualities which we have passed in review—altitude, duration of voyage, distance covered, velocity, power of transportation—have the common characteristic that they may be measured exactly, their value can be expressed in precise figures, and thus they furnish a fixed mathematical standard of comparison between different types of air machines, for they are based on rigorous observations, and questions of sentiment have not intervened. For instance, if the altitude attained should be taken as the criterion of the value of a dirigible, the one that has ascended to a height of 1,500 meters is incontestibly superior to one that has only attained a height of 1,200 meters. If it is a matter of distance covered, the one which in a single flight has traveled 800 km. is superior to one which has only covered 600 km. That much is perfectly clear.

There are other qualities, however, less exact in their nature, which, nevertheless, are not negligible, such as security, comfort and pleasure of voyage.

I do not care to enter into a detailed examination of these phases of the subject, partly because they cannot be exactly valued, and further because they are readily attained by devices of secondary importance. Thus by the use of flexible cushions and backs with head-rests the traveler's comfort is easily increased. These are questions to be referred to the skill of an upholsterer and not to an engineer.

There is, however, one property that is highly important for safety and comfort in a voyage—the stability of the vehicle. This stability is obtained by mechanism of a technical nature; it is often very difficult to obtain and therefore should be considered in connection with the more exact qualities first discussed. In a given vehicle, stability can be interpreted in several ways. The center of gravity of the apparatus can describe a very regular trajectory, but the vehicle may, nevertheless, be exceedingly unstable; it may go through oscillatory movements which are highly uncomfortable and occasionally dangerous. These movements have been given different names according to the direction they follow. When they are in a horizontal plane they are said to be zigzag movements or yawing. If it is a question of vertical movement, it may be of two sorts—in a longitudinal direction it is called pitching, and if in a transverse direction it is rolling.

Although displacements of this kind do not affect the trajectory of the center of gravity, and consequently cannot prevent the vehicle from following its course, they are none the less disagreeable, especially if several of them are combined. Stability of direction, longitudinal stability, and transverse stability, which will enable us to avoid, respectively, yawing, pitching and rolling, are, therefore, qualities highly desirable.

There is a fourth sort of stability that is a special quality of air-ships. This is stability of altitude. Land vehicles are forced to keep to the level of the ground on which they rest. Aquatic carriers float on the surface of the water; air-ships, on the contrary, and with them must be class submarines, are submerged in a fluid and can ascend and descend through the gaseous or liquid mass. When the air-ship remains at the altitude chosen by the pilot, or when it mounts or descends at his will, it is said to have stability of altitude. It does not have this quality when its vertical movements are involuntary and beyond the control of the aeronaut.

II

We have thus completed the enumeration of the qualities which an air-ship may possess. The question is now to choose from among them those most important in determining the value of the conveyance. But before making this choice it is indispensable to know from what point of view it is to be made. One may inquire as to which of these qualities is the most difficult to obtain. If the technical standing of engineers were to be determined that would be the course to pursue, and we should proclaim the superiority of the constructor who had endowed his machine with the qualities which are the hardest to attain. But it is not a question of awarding prizes to engineers. We want to know what air-ships have the greatest practical advantages. In making our choice of qualities we shall not demand, therefore, those most difficult of attainment, but those most desirable in themselves. We can afterward inquire if the most desirable qualities are more or less difficult to realize; this will be merely an accessory matter.

We are therefore called upon to pass judgment upon the practical advantages in types of air-ships. The first consideration is not to lose sight of the conditions under which by definition itself an air-ship is operated, conditions different from those which a boat or a railway train meets; no one can justly make an estimate of such dissimilar devices without recognizing the fundamental conditions of their utilization: that is, the nature of the supporting medium in which they move, the earth, water or air.

Locomotion on land brings into touch all the habitable places on the earth, except those separated from each other by expanses of water impossible to bridge. But from this advantage there is still an element of great disadvantage. To attain on land perfect conditions for speed and carrying power, it has not been enough merely to train animals or create powerful and ingenious machines. These achievements would not have counted for much unless the route had been prepared by the construction or roadways, involving an enormous amount of labor and money. Without highways and railways, automobiles and locomotives would be powerless. This is so true at the present day that the importance and the perfection of the ways of communication are considered the principal criteria of material civilization, and where these means are lacking we are no further advanced than were those of the days of Joshua.

A water transportation line, and herein lies its inferiority, only admits of the joining together of a very limited number of places, those along the shores of seas or along navigable streams. There is, however, the enormous advantage of not requiring a preliminary preparation of roadways. To travel by water, with all the perfection possible to obtain, it is only necessary to have good ships. The sea has at all times been the chief means of communication between the various countries of the globe; all the ocean shores have been fairly well known for a long period, while there have remained immense tracts of country unexplored in the interior of the continents. If, to venture an hypothesis, there existed in the center of Africa, or in the midst of the deserts of Asia, an unknown but populous city, the center of a flourishing civilization, the explorers who had discovered it could tell of its marvels on their return, but this newly discovered city would still remain apart from general civilization simply because it was not connected with other countries by perfected ways of communication. If, on the contrary, there should be discovered in the solitudes of the Pacific an islet, in itself of little importance, it could be brought into direct communication with New York, Marseilles, and Sidney, and enter immediately into the circle of mundane affairs.

Aerial navigation combines the advantages of its older sisters, and is free from their inconveniences. It can connect Paris and Rio de Janeiro as well as Madrid and St. Petersburg. It no more requires the preliminary construction of roads of communication than does maritime transportation. It creates direct bonds of communication without intermediary agencies, and to utilize it it is only necessary to have appropriate vehicles. Thanks to this means, all points on the globe may enjoy the privilege which has hitherto been reserved to the shores of the sea, and in a few years the atmosphere will certainly be the great medium for bringing people together, just as the ocean has been for a long time in its more limited and less perfect fashion.

THE CONSTRUCTION OF STANDARD CELLS AND A CONSTANT TEMPERATURE BATH*

G. A. HULETT

Summary.—The author discusses the preparation of the materials used in standard cells and the construction of the cells; he also describes a thermostat for maintaining the temperature constant to 0.01 degrees.

The one drawback of the Clark and Weston standard cells seems to be the mercury salt. It is a characteristic of mercury salts to hydrolyze, that is, to interact with water and form a basic salt and acid, and mercurous sulphate is not an exception to this rule. Sulphuric acid and sulphate solutions prevent or decrease this hydrolysis, and the hydrolysis of mercurous sulphate in a zinc sulphate solution has not been detected, but it is surely present in a cadmium sulphate solution. Such a reaction need not detract from the value of the cell, for equilibrium is established as soon as the basic salt and a definite acid concentration are present, and then the potential is again a function of the temperature only. In the Clark cell the reaction has not been detected, but in the Weston standard cell the hydrolysis takes place, although it is a very slow change which does not come to equilibrium. However, this change is generally small as well as slow, and the cell has other qualities which make it valuable.

As to the reproducibility of the cells, pure redistilled mercury may be obtained from reliable dealers and answers every purpose. In lieu of this, ordinary mercury is chemically purified and then distilled.

MERCUROUS SULPHATE

The depolarizer is chiefly responsible for variations in the reproducibility and constancy of standard cells. The first explanation of the changes which caused the trouble was offered by Carhart and Hulett; evidence was given to show that the irregularities in the standard cells were due to the presence of a basic mercurous sulphate which had been formed in preparing the mercurous sulphate or in making the paste. It was also shown that mercurous sulphate is stable in a sulphuric acid solution when the concentration of the acid is molecular (98 grammes H_2SO_4 to a liter) or greater, but when the acid strength drops below this value the mercurous sulphate begins to hydrolyse with the formation of a basic salt, soluble with difficulty—$Hg_2(OH)_2.Hg_2SO_2$. It was, therefore, found possible to suggest conditions for preparing the mercurous sulphate and making the paste so as to exclude the basic salt. The cells made under these conditions did not require the usual aging, but showed a constant value at once, and were in exceptionally good agreement.†

It is easy to prepare mercurous sulphate chemically and with sufficient sulphuric acid present to prevent hydrolysis, but there is the inclusion and isomorphism of nitric acid, nitrates or other substances to be considered, and while the depolarizer made by these chemical methods does, with the proper precautions, give correct values to the standard cells, it is our experience that the electrolytic mercurous sulphate gives on the whole the most uniform and reproducible values.

The electrolytic method has the distinct advantage that only mercury and moderately dilute sulphuric acid are used and the only foreign substance to be looked after is sulphuric acid which may be effectively removed as indicated below. We used an acid having a density of 1.15, made by pouring one volume of concentrated sulphuric acid into six volumes of water. When this acid is electrolyzed between a mercury anode and a platinum cathode, mercurous sulphate is formed and goes into solution at the anode, but when the acid is saturated (0.2 gm. Hg_2SO_4 to the liter) the solid mercurous sulphate appears and covers the anode. At the cathode, hydrogen is liberated and a little mercury forming about 9 gm. of the salt per ampere hour. If the

*Abstract of an article in the *Physical Review*.

†"Trans," Amer. Electrochem Soc., 5, 71.

mercurous sulphate is allowed to collect on the anode to any great extent, a secondary reaction may take place, but this is to be avoided, and a stirrer has been employed to keep the mercurous sulphate in suspension in the electrolyte while the current was passing, but only a limited amount of mercurous sulphate could be formed at a time.

Lately, we have improved the method by using an inner dish to hold the mercury and so arranged that the mercurous sulphate passed over the rim of the inner dish and collected in the space between it and the outer dish. Fig. 1 shows the arrangement.

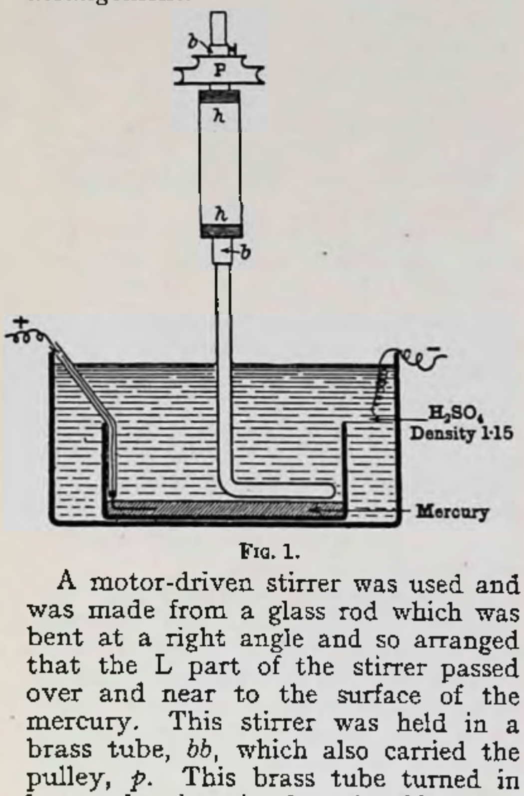


Fig. 1.

A motor-driven stirrer was used and was made from a glass rod which was bent at a right angle and so arranged that the L part of the stirrer passed over and near to the surface of the mercury. This stirrer was held in a brass tube, *bb*, which also carried the pulley, *p*. This brass tube turned in bronze bearings in the tube, *hh*, which was firmly held by clamps (not shown). It was found to be important to have the stirrer well made so that it worked smoothly and with certainty.

After the stirrer was running uniformly at the rate of some 200 revolutions per minute, the current was turned on. With fresh acid a skin formed on the surface of the mercury; but by breaking-and-making the current several times until the acid became saturated with the mercurous sulphate and the solid sulphate appeared throughout the acid, there was no further trouble. The position of the stirrer was such that it did not unduly agitate the mercury. The mercury sulphate formed was carried up by rotating liquid and settled in the space between the two dishes, and much more readily when the rotation of the inner dish was retarded. This was easily accomplished by inserting glass plates edgeways down into the acid and allowing them to rest on the edge of the inner dish. With a current of from 1 to 2 amperes per 100 square cm. of mercury anode surface the product obtained was gray, due to finely divided mercury. The presence of this finely divided mercury is an advantage in checking any tendency to oxidation. Generally, 50 or 60 gm. were prepared at a run, and after the stirrer had been removed and the mercurous sulphate had settled, most of the acid was removed; the contents of the inner dish were poured into the outer dish and all well stirred for some time; then the acid, with the suspended sulphate, was poured into a clean dish, and after the sulphate had settled the acid was returned to the mercury, stirred, and again decanted, and this was repeated until the mercury and mercurous sulphate were separated. The product was transferred to a glass-stoppered bottle, covered with a little of the acid and kept in a dark place until needed.

Our experience is that this gray electrolytic mercurous sulphate, prepared as just described, is the most reliable reproducible depolarizer for standard cells, and that the grains are sufficiently large to avoid all effects of surface tension.

FLOWING ANODE METHOD

Lately, we have also used an interesting and very simple method for preparing electrolytic mercurous sulphate. A fine stream of mercury flowing from a funnel into the sulphuric acid is made the anode and no stirring is required. Fig. 2 illustrates the apparatus. An ordinary funnel was used, the stem was warmed in a flame and drawn down to a capillary, which was about 10 cm. in length and of such a diameter that 10 cu. cm. of mercury were delivered in about five minutes. An ordinary liter beaker glass was filled nearly full with the sulphuric acid (density 1.15) and the funnel adjusted so that the tip of the capillary was just under the surface of the acid. A short platinum spiral was hung in the acid and served as cathode, mercury was poured into the funnel, ran through the capillary and formed a spray as it entered the acid; but when contact was made with the mercury in the funnel and a current from 2 to 3 amperes was passed, the spray changed to a cylinder of flowing mercury which extended to the bottom of the beaker and looked like a wire. It was distinctly gray save for a short distance at the top, which was bright mercury.

M. Coste and M. Etaix have used an alternating current in preparing mercurous sulphate. The flowing electrode method also permits us to use an alternating current and very simply. Two funnels were prepared with the same length of capillary stems and of the same diameter. These funnels dipped into the same beaker of sulphuric acid and the two streams of mercury were used as the electrodes. A 60-cycle alternating current was used and so regulated that there was no arcing between electrode and electrolyte, and thus a current of about 5 amperes was used. The efficiency here is as great as with the direct current, about 9 gm. of mercurous sulphate per ampere-hour.

With the flowing anode method the preparation is white, even with large current densities, and the sulphate is easily separated from the mercury by decanting it with the electrolyte. Cells made with these preparations as depolarizers show a slightly higher value than with the gray electrolyte previously described. The alternating current preparation seems to be the better of the two, but they have not been tested for a sufficient length of time if we are concerned with the fifth decimal place in the e.m.f. of the cells.

THE PASTE

The problem is to prepare a mixture of mercurous sulphate, zinc or cadmium sulphate and saturated solution, but to avoid the presence of sulphuric acid and basic mercurous sulphate. The only impurity in the electrolytic mercurous sulphate is the sulphuric acid in which it is made and preserved; but any attempt to remove this acid by washing with water introduces the basic salt. Formerly we used alcohol, which was subsequently removed by washing with the saturated zinc or cadmium sulphate solution, but we have found that this preliminary washing with alcohol is not necessary and that really only three washings with the saturated sulphate solution are necessary, when certain precautions are observed. (A Gooch crucible, filtering apparatus and good suction were employed.)

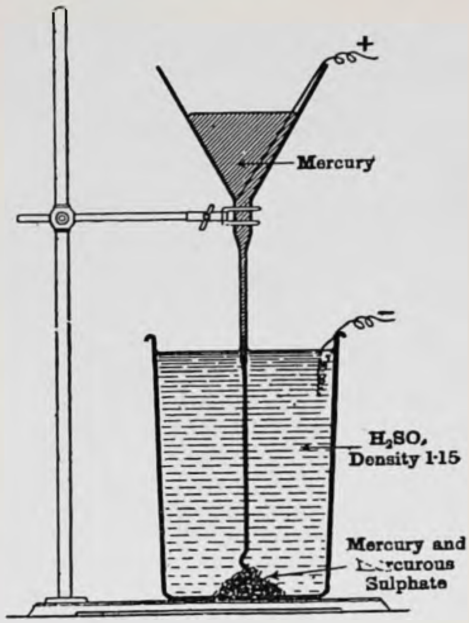


Fig. 2.

A large agate mortar was used in mixing the components of the paste. Zinc or cadmium sulphate crystals, about equal in volume to the mercurous sulphate, were crushed, a few cubic centimeters of the saturated solution being first added to the crystals to prevent partial dehydration by the crushing. After the crystals had been ground to a fine powder, the mercurous sulphate was added and all thoroughly mixed with enough of the saturated solution to make a thin paste and of such a consistency that it readily flowed from a 5 mm. tube. Unless the mercurous sulphate was gray a little mercury was ground up with the crystals and mixed with the paste. In all the operations of preparing the depolarizer and making the paste, direct sunlight or undue exposure to light was avoided.

ZINC SULPHATE

Zinc blend, from which this salt is obtained, generally contains cadmium and manganese and often lead and tin. The salt is isomorphous with the other vitriols—iron, magnesium, cobalt, nickel and copper, but none of these metals, in the small amount usually found present in zinc sulphate, seems to affect the e.m.f. of the Clark cells. Sulphuric acid is to be excluded. Zinc sulphate as obtained in the trade generally contains less than the theoretical amount of water of crystallization, due to efflorescence, so it is best to recrystallize the salt, and at room temperature, in order to ensure the heptahydrate.

ZINC AMALGAM

Zinc is one of the more soluble metals. With an excess of zinc we have, for each temperature, a liquid amalgam of definite composition, and in equilibrium with a solid phase which is pure zinc.

The liquid amalgam contains:

At	0 degrees	1.35 per cent. of zinc
	15 degrees	1.74 per cent. of zinc
	20 degrees	1.99 per cent. of zinc
	25 degrees	2.18 per cent. of zinc
	39 degrees	2.85 per cent. of zinc

There seems to be no difference between the potentials of amalgams made from "chemically pure" zinc and mercury and amalgams made from the most highly purified metals, so the "chemically pure" materials serve every purpose. Zinc dissolves but slowly in mercury, and the amalgam oxidizes readily when hot, but we have had no trouble with this amalgam since using the following method: a 2.5 cm. hole was cut in a piece of asbestos cardboard and an ordinary porcelain crucible was pushed into this hole so that it was about half way through, the board was placed on a tripod and the crucible was charged with 7 gm. of chemically pure zinc; and then 13 times the weight of mercury was added. A small adjustable Bunsen flame was placed under the crucible and the contents heated, but without stirring, until the zinc had all dissolved. This takes a temperature near to the boiling point of mercury, and the crucible was covered with a little watch glass. The flame was now pushed a few centimeters to one side, and when the crucible cooled down to about 100 degrees, the amalgam was readily transferred to the cells with a pipette.

CADMIUM SULPHATE

$3\,CdSO_4.8H_2O$ is a very soluble salt, but is peculiar in that the *rate* of solution is exceptionally slow, so that considerable attention is needed to prepare a saturated solution. The solubility changes only slightly with the temperature and the 8/3 hydrate is stable up to 74 degrees, where it changes to the mono-hydrate. Cadmium sulphate does not seem to be isomorphous with any known salt, and consequently is obtained in a sufficiently pure state in the trade; but one may obtain such beautiful crystals that it is worth while to recrystallize the salt. Attention is to be given to the preparation of a saturated solution of cadmium sulphate, on account of the slow rate of solution of these crystals; 100 cu. cm. of the saturated solution requires 75 cu. cm. of water and 86 gm. of the crystals, but a considerable excess of the crystals is to be used and stirred over night with a motor-driven stirrer.

CADMIUM AMALGAM

Cadmium is the most soluble metal in mercury; the saturated amalgam contains the following percentages of cadmium:

At	0 degrees	2.5 per cent.
	15 degrees	4.4 per cent.
	25 degrees	5.6 per cent.
	35 degrees	7.1 per cent.

With an excess of cadmium the solid phase is not cadmium but an isomorphous mixture of cadmium and mercury. In view of the great solubility of cadmium at ordinary temperatures it does not seem well to use less than 8 per cent. of cadmium in the amalgam. The question of equilibrium in this amalgam needs further investigation; it is a much more complicated system than is the zinc amalgam. We have used for some time a 10 per cent. amalgam for our cells and make it quite accurately and uniformly as follows: 99 gm. of mercury were placed in a little crystallizing dish, 5 cm. or 6 cm. in diameter, and 25 gm. of the clear cadmium sulphate crystals

(43.82 per cent. Cd) were placed on this mercury and then about 50 cu. cm. of distilled water were carefully added and made acid with a drop of sulphuric acid. A flat platinum spiral was so adjusted that the spiral was just beneath the surface of the water and contact was made with the mercury which was cathode. When 2 or 3 amperes were used, the cadmium was deposited in the mercury about as fast as the sulphate dissolved; then, when the crystals had all disappeared, the current was increased to 4 or 5 amperes for half an hour. This insured a complete deposition of the cadmium and also liberated enough heat to melt the amalgam. The acid was finally removed by a pipette or syphon and at the same time distilled water was run in. This washing continued until the current dropped to zero.

We have prepared cadmium sulphate and cadmium of the highest degree of purity, also zinc sulphate and zinc, and constructed cells with these materials, but the e.m.f. of these cells did not differ from that of the cells made with materials prepared as described above. This result is what we would expect when we consider the factors controlling the potentials at the anodes and cathodes of these standard cells.

THE GLASS PARTS

The "H" cell proposed by Lord Rayleigh has proved to be the most practical form of cell. It is easily filled and allows the contents of each electrode rapidly to take up the temperature of the bath. The 0.2 mm. platinum wire leads are sealed through the glass so that all but the tip end is covered with a sheath of glass. The wire is first sealed in so that the end is only just through the glass and then, while the glass is still soft, the wire is pushed in about 5 mm. and covers itself with a sheath of glass, leaving only the tip exposed. Wires sealed in this way give uniform contact with the mercury or amalgams and are less liable to cause subsequent cracking of the glass, especially when a fine wire is used.

The mercury, amalgam and paste are each from 10 mm. to 15 mm. in depth. A few crystals are placed on top of the paste and on the amalgam a layer of crystals not over 10 mm. in depth. Only a small amount of the crystals are necessary for either the Clark or Weston cell, while a large excess may grow together and cause trouble. The cell is filled to the top of the cross tube with the saturated solution, and then the glass parts are sealed off 2 cm. or 3 cm. above the liquid by using two small blast flames which impinge on opposite sides of the point to be sealed.

The difficulties we have encountered with these cells are the tendency of the glass parts to crack (which is most pronounced in the amalgam leg of the Clark cells), and the fact that the contents of the cell are not accessible. This difficulty was recognized by Lord Rayleigh in recommending the cork seal. The trouble with this has been that the cork was generally in contact with the liquid and so leaked sooner or later. We have used for some time a form of cell which avoids these difficulties; the glass part is the simplest possible (Fig. 3). Thin-walled tubes, 20 cm. long and 12 mm. in diameter, are closed at one end and blown out at the side about 5 cm. above the closed end. Two of these tubes are joined directly together, giving the advantages of the test-tube form. No platinum wires are fused into this part of the cell. These cells are closed by corks which are 15 cm. above the liquid of the cells and are never wet, and do not need to be covered with wax. These corks carry the long narrow tubes which enclose the contact wires, and these may be removed and replaced at any time. This long form of cell is found to have many advantages in handling in the bath; several may be bound together in a very compact form and the contents of these cells most readily take on the bath temperature, while the insulation is perfect in any kind of a bath liquid.

The details of the contact wire and protecting tubes are also shown in Fig. 3. A piece of tubing 3 mm. in diameter is softened in the flame and drawn down so that the part which is to pass through the contents of the cell is not over 2 mm. in diameter. This narrow part is about 6 cm. long, while the total length is about 22 cm. A piece of 0.1 mm. platinum wire about 10 cm. long is soldered to a 20 cm. piece of silk-covered copper wire

(No. 32). This wire is passed into the protecting tube until the platinum wire projects 1 or 2 mm. from the narrow end of the tube and this thin end is sealed in the flame. A bit of wax is run into the upper end to hold the wire securely. Six cells are made at one time and all bound together, and then the negative or anode wires are twisted together and the exposed ends soldered so that only one contact need be made for the anodes of all six cells. The positive or cathode wires are scraped to remove the covering, and then each one is wound about a small piece of millimeter copper wire which is forced into the warmed wax in the top of the tube leaving about a centimeter exposed, and here a good contact is easily and rapidly made with a pinch connector. It is well to amalgamate the platinum tip of the contact wire just before it is inserted into the contents of the cell. This is readily done by holding it for a few minutes in boiling mercury (in a test tube.)

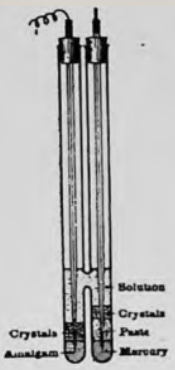


Fig 3

Fig. 4.

E.M.F. OF STANDARD CELLS

We have made both Clark and Weston cells at intervals since 1903, and according to the preceding specifications. A dozen Weston cells, made at one time, often agree among themselves to 1 part in 100,000, but in time the agreement is not so good; in a year or so the variations may be noticeable, and when compared with a freshly-made set of these cells it has been found that all the older cells have decreased, and some of them very noticeably. Clark cells have also been made at intervals during the last seven years and the agreement among themselves of any "set" of these cells is about the same as that of the Westons; but the Clark cells made at different times are in better agreement, and none of them have shown an e.m.f. decreasing with time, such as is noticed in some of the Weston cells. It seems necessary, therefore, to make the Weston cells at intervals of about six months and reject those which fall to low values. We make both Clark and Weston cells at such intervals, and the cells are kept all in a constant temperature bath which does not vary over 0.01 degrees from 25 degrees. Taken all together these two kinds of cells with the aid of a thermostat give us a standard which is independent of time and is reliable and reproducible to one or two parts in 100,000. The value in absolute units of this standard of e.m.f. is, of course, not known to anything like this degree of accuracy, but whenever the absolute value is more accurately determined, all work which has been based on this constant may be recalculated if necessary, so we are justified in giving the assumed value to the fifth decimal place. Assuming that the Clark cell gives 1.4330 volts at 15 degrees, and using the customary temperature formula the Weston standard cells are found to have the value 1.01840.

THE THERMOSTAT

The Weston cell has only about one-thirtieth of the temperature coefficient of the Clark cell. This was a decided advantage before thermostats were used, but for electrical measurements which make any pretence to accuracy an automatically controlled bath is indispensable for both types of cell, so the temperature coefficient is of no consequence. It is our experience that it takes a considerable time at a given temperature for *all* the cells of a set of standards to attain their true value. We generally allow a week. It is, therefore, necessary to have an automatically controlled bath, and 25 degrees have been chosen. Our thermostat is an electrically heated and controlled kerosene bath which keeps well within 0.01 degrees for any length of time. It consists of a tank made from galvanized sheet iron, 50 cm. by 65 cm. and 50 cm. deep, which rests in a box on legs. The space between the box and the tank (6 cm.) is packed with excelsior, and the top of the tank projects about 2 cm. above the top edge of the box. A cover, 100 cm. by 100 cm., was provided, and the centre (50 cm. by 65 cm.) cut out so that the top of the tank fits into this place and is flush with the top of the table part when assembled. Plate glass strips of convenient widths cover the tank proper. About 100 liters of kerosene serve as the bath liquid, and are found to be very clean and easily kept dry by a dish of calcium chloride suspended in the upper part of the tank. A motor-driven stirrer was necessary.

The regulator and heater have received most attention, the aim having been to get large surfaces well distributed in the bath liquid. Both the regulator and heater are supported by a frame about 10 cm. above the bottom of the tank. This frame was made of brass tubing, 40 cm. by 55 cm., with two cross pieces, and is supported by four legs. Fastened to the under side of this frame is the glass part of the regulator (Fig. 4), which contains the toluene and mercury, and the expansion or contraction of these liquids makes or breaks a contact of the relay circuit and so controls the heating current.

Sparking between the mercury and the platinum point causes the mercury to become "dirty," changes the meniscus, and thus causes slow drift of the bath temperature. It is customary to put a condenser in parallel with this contact, but we have had much better results by arranging to use a small current of low voltage in the relay circuit. We find that our mercury contact surface remains perfect for months at a time and makes-and-breaks contact with the platinum point at exactly the same temperature.

With the arrangements we have, the heating current is made or broken by a change in the bath liquid of only one or two thousandths of a degree. For constancy, and to avoid oscillations of the bath temperature about the desired point, it was necessary to have the bath well insulated. This was accomplished with the 6 cm. of excelsior packing between the tank and containing box and the plate glass cover. Also, it was especially important to have a small amount of heat liberated in the unit of time, and well distributed in the bath liquid. Our heating coils consist of 0.25 mm. nickel wire wound on 10 mm. glass tubes shellacked to hold the wire in place. The resistance of our coil is about 120 ohms and is connected with the 110-volt alternating current lighting circuit, but we also use an external resistance, as 0.4 ampere is sufficient to control the bath, even with very considerable variations of the room temperature.

Babbitting Eccentric Straps

It often becomes necessary to babbitt or re-babbitt an eccentric strap in an engine room. While this job is one somewhat dreaded by those not familiar with the work, it is simple if gone at in the proper way. Like all babbitting jobs, if you properly prepare for the job, you will have but little trouble doing it. Sometimes an eccentric becomes very much cut and it is necessary to babbitt it to make it so that it can be run. Sometimes it is necessary to file the entire eccentric block, which can be easily done, but care must be taken not to file flat places; one should file gently all around the entire surface of the block until smooth; you need not file out all of the cut marks on the eccentric strap, but the surface should be fairly smooth.

When you have finished the filing make a dressing clamp shown in Fig. 1, which can be made of some small pieces of timber. Use some emery cloth beneath a small rubber block; this block can be made of any kind of wood, soft wood will serve just as well as hard wood. The outside frame of this truing device should be bolted up firmly and the tension set on by the auxiliary block. This is a simple tool, but one of much value, and it will work wonders on an eccentric that is giving trouble, as it will true up the surfaces and not leave bumps that would cause the bearing to run hot when started. It should be used with some diligence and care to insure a good surface. The block can be made to conform to the shape of the eccentric. When the eccentric has been properly prepared the strap can be babbitted. If it is a strap where iron to iron has been working the best plan would be to take the strap to some nearby shop and have it turned out so as to make room for babbitt, provided the strap has strength enough.

I have found in some cases, where much trouble was being experienced from the running of an eccentric, an excellent plan is to have a new cast-iron strap made, allowing the proper babbitt room, as babbitt running on cast iron is far better than running two like metals together.

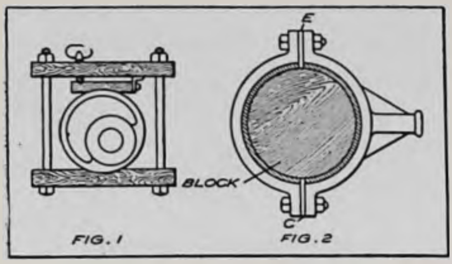


FIG. 1. DRESSING CLAMPS FOR ECCENTRIC
FIG. 2. BABBITTED CAST- IRON ECCENTRIC STRAP

There are two ways of babbitting the strap. One is to babbitt it on a form or block and have it turned out on a lathe to fit the eccentric. This makes a fine job when carefully done. In this case the babbitt can be poured in the strap as shown in Fig. 2, the strap being nicely centered up around the block and must have the necessary liners in the clamps at *EC* and the strap must be firmly bolted together. These liners preferably should be metal so as not to give from their original place when being re-clamped. The block may be nailed or fastened down.

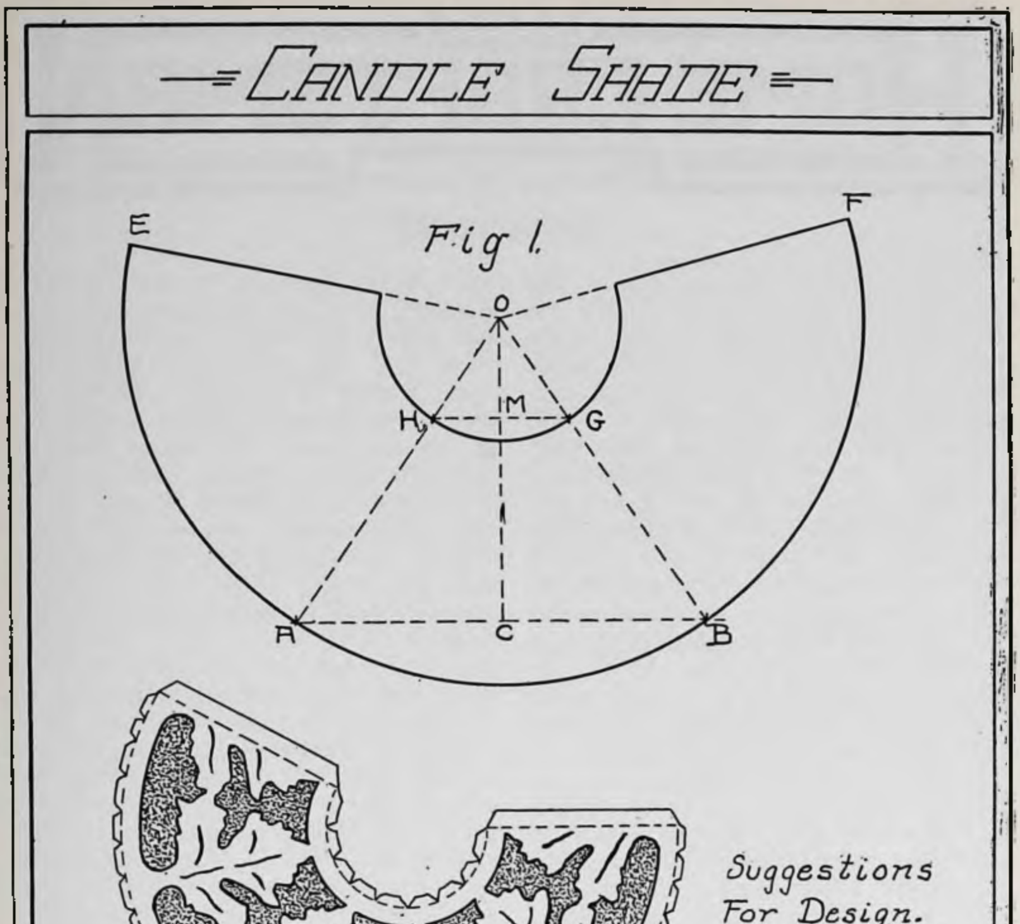
When the babbitt has been poured the strap is ready for the lathe. It should all be turned as a solid mass and then sawed apart and the proper gap filed between the openings. When this has been done, fit it to the cam. It should need but little fitting if the measurement has been carefully taken to the lathe man. When keyed on and found to be all right, cut some deep oil grooves and place the strap on eccentric, bolt it up firmly, and before connecting up the eccentric rod turn the strap around to see that it is free. Many strap jobs prove disastrous by failing to do this and will stick upon starting and break things up.

Some of our engine rooms are far from a lathe, and we have to babbitt an eccentric strap right in place. This is usually, however, the kind that has been once babbitted. To do this, clean out the old babbitt and dress the eccentric block in the same manner if it is untrue. When ready to babbitt have two circular boards made so that they can be clamped over the shaft. Clamp these on each side of the eccentric and this job must be well done so as not to give away. The strap can be centered in place by placing some small pieces of babbitt around between the strap and the blocks; the strap must be firmly bolted upon the liners between the strap ears. In this case a pouring hole is left at the top. After clamping up the boards firmly some putty should be put around the crevices so that no metal can leak out when pouring, as a leak will necessitate doing all the work over again, so this is one of the points that should receive the proper amount of care. When the pouring is finished take the bolts out and break apart the strap and dress and fit by scraping, and cut the oil ways. This should be done in the same manner as in the other case cited. The points of the strap should always be relieved with a scraper so as to allow plenty of freedom for expansion. This is one point where many babbitting jobs become a failure. A strap which has been poured on the eccentric block and not turned out will require more relining at this point than one that is turned, on account of contraction from the heat of the babbitt.—C. R. McGahey in *Practical Engineer.*

What One Firm Pays for Patents

A recent report of the General Electric Company, covering the period of the eleven months ending December 31, 1909, contains some remarkable figures. During the fiscal year, the company paid for patents and patent litigation, the sum of $904,207, which sum is not counted as an asset, but is charged over to profit and loss. All the company's valuable patents, franchises and good wills stand in the balance sheet at a nominal valuation of one dollar.

A foot-pound saved at a bearing means ten saved in the coal pile.


CANDLE SHADE
Fig 1.
E
F
O
M
H
G
A
C
B
Suggestions
For Design.
11
R.F.W. 1911.

THE HOME CRAFTSMAN

RALPH F. WINDOES

CANDLE STICKS

Another small article which the amateur craftsman should have no trouble in working out is the candle stick. A well-designed candle stick should be beautiful in shape and construction, as the utility side of it will almost take care of itself. We may bore a hole in any kind or shaped piece of wood, put a candle into it and call it a candle stick, but we, as craftsmen, must make the shape of that piece of wood as pleasing to the eye as possible.

Now in designing a candle stick the first thing we must consider is the use to which it is to be put. If we are going to make one or two to ornament a mantel and put shades upon, we must make them much taller than they are wide, but if we are making one for practical use, that is, to carry around from place to place, it had better be a low one, much wider than it is high. The candle sticks here illustrated are both of the former class and should have candle shades put upon them.

The stick at *A* is extremely beautiful when made of quarter-sawed oak, weathered finish, and trimmed with highly polished brass. Another very pleasing effect is produced when the wood-work is of mahogany and the metal work copper.

The material needed for one of these sticks in oak is as follows:

1 piece ½ x 4 x 4 in. oak
2 pieces ½ x 2 x 15 in. oak
2 pieces ½ x 3 x 15 in. oak.

The above must be finished to the given dimensions.

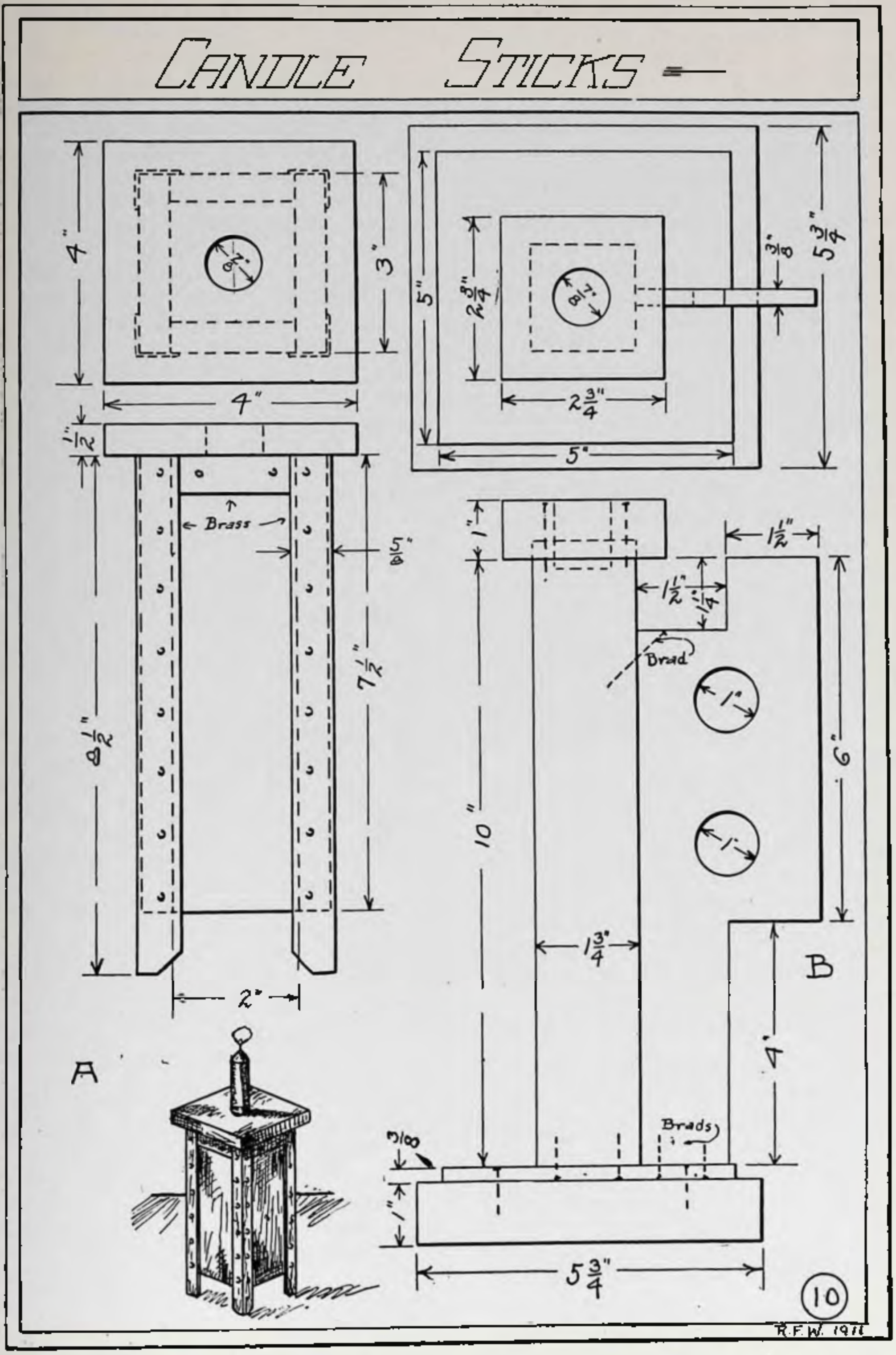
1 piece 20 gauge brass 5⅝ x 8½ in.
Few 1 in. brads
Few ½ in. brass escutcheon pins
Steel wool, lacquer, stain, filler and wax.

The first step in the construction of the stick is to scrape and sand the lumber until it is extremely smooth. Next cut the two 15 in. pieces in two, and nail them together as shown in the drawing, making a square box. Now cut four strips from the brass 1¼ in. wide and 8½ in. long. This should leave a strip ⅝ in. wide. These 1¼ in strips must be bent to form a right angle at their center. This may be easily done by placing them, one at a time, between two hardwood boards, so that one-half projects above the boards. Fasten securely in the vise and pound this projecting strip over with the hammer until a right angle is smoothly formed. Cut the inside corners off one of the ends of each strip and fasten them onto the corners of the box with the escutcheon pins as shown in the drawing. Next cut the ⅝ in. strip into lengths that will fit between the brass corners, and nail as seen under the top piece. All that remains of the construction of the stick is to put on the top with brads, the heads being sunk and filled, and the boring of the hole to contain the candle. In nailing on this top it is well to hold the stick in the vise so as not to bend the legs when pounding down upon them. Or the stick may be placed on a small block, about 3 in. square, during this operation.

Next the wood should be filled, stained and waxed, processes that the craftsman has gone over so many times, no doubt, that nothing more need be said about them here. When the finish has hardened, the brass work should be highly polished and lacquered with banana oil. Be careful that the lacquer does not run onto the wood as it will spoil the polish on the latter.

The craftsman may lessen his work somewhat by finishing the wood-work before putting on the metal.

The candle stick at *B* is purely mission in design, and is made entirely of oak. The material needed for one of these is given below, the lumber being sanded to these finish sizes.


CANDLE STICKS
Brass
Brad
Brads
A
B
10
R.F.W. 1911

1 piece 1¾ x 1¾ x 10⅜ in. oak
1 piece 1 x 2¾ x 2¾ in. oak
1 piece 1 x 5¾ x 5¾ in. oak
1 piece ⅜ x 5 x 5 in. oak
1 piece ⅜ x 3 x 10 in. oak
Brads, filler, stain and wax.

First mortise out a place in the small top piece ⅜ in. deep to receive the top of the body of the stick. Nail this in place, being sure to put the brads where they will not interfere with the bit when the candle-hole is bored. Next nail the square piece ⅜ in. thick onto the bottom of the main piece, as seen in the drawing. Following this, form the handle to shape and dimension, as shown, and nail it to the parts already constructed as illustrated by the dotted lines in the drawing. Attach the base with brads and bore the candle-hole. Set all the brad heads that can be seen and apply the finish to the piece, being sure to fill up all of the head holes.

CANDLE SHADE

The true craftsman will not be content with a candle shade purchased at a dealer's, already to be pierced and put together, but he needs must make his own after his own design. Hence, this article has been put in as a suggestion and a means of guidance for the true craftsman.

First he must have a pattern the right size, and it must be laid out with instruments so that it will be absolutely correct when put together. This is an easy task if care is taken and the directions followed explicitly.

There are two sizes for candle shades that can be selected. The smaller is: 6 in. across the bottom; 2 in. across the top; 3 in. high. The larger is: 7¾ in. across the bottom; 2 in. across the top; 4 in. high.

After deciding which size you intend to use look at Fig. 1 and prepare to lay your shade out accordingly on a piece of paper. First draw AB and CO perpendicular to it, any length. Lay off AB equal to the top diameter of the shade chosen and CM equal to the height. Draw HG parallel to AB and equal to the top diameter. Connect B and G and A and H, and continue them until they meet at O. With O as center draw the arcs as shown through A and H. Measure three times AB on arc $EABF$ and add one eighth of an inch for every inch in AB, locating E and F which are drawn to O.

This gives you the true pattern of your shade, but laps must be added as shown below Fig. 1, in order to hold the shade together and to stiffen the edges. These laps should be about ½ in. wide where they fasten together, and about ¼ in. around the circular portions. After this has been laid out carefully, draw your design in on this paper. Notice the suggestions given. The first is a leaf repeat and the second an entirely conventional design. The craftsman had better make up his own design, but in so doing there are a few things that he must observe. First, do not make the design so small that there is too much background, nor so large that there is too little. Second, make it artistic. If you are no artist you had better copy a design rather than spoil your work by a poor design, though I strongly advise that the craftsman do his own designing. Third, leave a margin at the top and bottom of the shade, and work your design into it if possible, as those here illustrated have been.

After the pattern and design have been carefully worked out, transfer them to a piece of 30 gauge copper or brass with carbon paper. Tack this to a piece of soft wood and begin the piercing. Piercing tools may be purchased or made at home from steel. Wire nails are rather nice, but the point does not last long enough. An awl may be used to good effect.

Begin around the edge of the design and pierce small holes rather close together. Some craftsmen pierce the veins of leaves, etc., but it is a good plan not to do this, simply the outline of each part. When this is complete pierce the entire background with larger holes farther apart, made by hitting the tool harder with the hammer. This throws the design into relief, that is, it makes it stand out away from the background. Next make a veining tool from some metal and press it down firmly over each vein in the design and also around the pierced edges. This tool is made by rounding the end of a nail off so that it does not cut or scratch the metal when drawn over it, but simply presses the metal down. When this is complete cut the shade out with a pair of snips and bend the edges over evenly. The end laps that hold the shade together may be bent straight in, holes pierced through them and wired tightly together; or they may be lapped and fastened with pin head fasteners which are purchased at an art store.

Next, the shade should be polished and lacquered. If the glass bead fringe is desired it may be purchased in a variety of colors and fastened from the inside of the shade with the fasteners that come with it. It adds much to the appearance of the shade and should not be omitted.

Candle shade holders are for sale at the art stores, and they serve their purpose very nicely.

(To be continued)

ENGINEERS IN THE MAKING

H. WINFIELD SECOR

In this age of marvelous achievements and inventions, one does not always stop to think what made them possible; of the vast amount of diligent study and patient research on the part of those who are responsible for these productions of twentieth century brains and energy, such as modern skyscrapers, flying machines, transmitting intelligence without wires, X-rays, seeing over a wire (which will undoubtedly soon be accomplished), etc.

To those who are more or less familiar with the work entailed in developing such branches of applied science as these, there is generally one man of whom they think first, the engineer. He it is, who has been responsible for the success or failure of the scheme, whether great or small, since its first inception until the finishing touch has been applied, and it starts in to do its quota of the world's work.

The engineer, of whatever variety he may be, electrical, mechanical, mining, or aeronautical, is generally supposed to be a product of some university or college, from which he receives a degree, certifying that he has passed the prescribed course of studies necessary to qualify him for that particular mark of learning.

And who will gainsay that the engineer who is a college graduate is not far ahead, with few exceptions, of another man who should study over the same length of time, from regular text-books? To begin with, the college man has had the benefit of careful and thorough study in finely equipped laboratories. He has had the opportunity to try out the problems given in the text-books with actual apparatus, and could note its every action.

Then he has had to study literature, history, the languages, philosophical subjects, etc., which have certainly broadened his mind and will make him more far-reaching in his accomplishments after graduating; and, last but not least, he has had the undeniable benefits of personal tuition, with its consequent social effect on his character, all tending to make him a finished scholar.

Leaving the college-bred engineer, who is usually well provided with funds by his parents, although some manage to work their way through, we come to that class of men who aspire to become engineers, yet who cannot afford to go through a university, which usually costs from $3,000 to $5,000 for four years' work. To this class of aspirants, there is opened the path to engineering studies by correspondence, the student perusing his lessons at home, and then sending his examinations to a tutor at the school; the corrected examinations, with thorough explanations, being sent to the student by return mail.

There are several good correspondence schools teaching engineering studies now, and several of the universities (including the University of Chicago) have awakened to the fact that with properly prepared instruction papers and a student of average intelligence, all of the studies in the regular curriculum may be taught as well as if he were a resident student.

It is an undisputed fact that mathematics, history, languages (by aid of phonograph), literature, drawing and other similar studies may be pursued equally as well at home as at the school. A good proof of this fact is to go into any large drafting room of a manufacturing concern, and you will find that 50 per cent. to 75 per cent., and possibly more of the men employed are graduates of one of the leading correspondence schools, and a great many times they are called upon to do considerable calculating, and the way they do it proves the fact above stated. The writer knows several such men, who work side by side with college graduates.

Now comes the stage that most concerns the college man, and which determines whether or not his co-contestant for engineering laurels shall stay in the race or remain at the draughting board, copying from sketches and designing details, for drafting is only the beginning of an engineer's career.

The next stage is the practical application of advanced engineering technics, and the correspondence school graduate may follow the college man in the theory, but how about the practical experience? True, the college graduate may have had but little practical experience, but his actual working experience in the laboratory will not fail him, and he will in most cases be able to enlarge on it, and thus, by combining practice with theory, produce a harmonious result. But the correspondence school graduate is up against it, good and hard, for he has received no practical experience, and would not know a piece of steel from a piece of cast iron, in the majority of cases.

However, it is good that the brand of purely theoretical engineer, as turned out by the correspondence school, is in the big minority, and we generally find their students, a class of brainy, persevering, ambitious men, who are either learning a trade, or who are already master of one, and the result of their correspondence studies are combined with practical experience, producing a good working union of the two; and if the man having these qualifications is of the right caliber, and filled with the fire of attaining better things which knows no quenching, then he is bound to succeed, and he will find there is plenty of room at the top of the ladder.

The ordinary correspondence schools are not decreed by law to confer degrees for following any of their courses; a diploma being awarded to successful students, however, attesting to the fact of their having successfully passed the required examinations.

The universities referred to, who conduct correspondence study departments, give only two or three years' work in this manner, and the final work must be taken at the university, and this is a very good plan.

For those who might wish to take up a complete course by correspondence, leading to any of the regular collegiate degrees, such as E.E., M.E., B.Sc., etc., The National Correspondence Institute of Washington, D.C., is the only one known at present. They are decreed by U.S. law to confer degrees, and of course, as might be expected, their courses are the complement of the regular college courses. One can follow here an E.E. or M.E. degree course for $200, or a B.Sc. course for $600.

The writer trusts that he may have been successful in raising the hopes of some of those who wish to attain better positions in the world, and that they will take a new and firmer grip on the plain truth of that supreme statement "Knowledge is Power."

Finishing a Bearing

HERBERT CHARLES

After babbitting a journal, trouble is sometimes experienced in making it run cool, until it has worn down to a bearing, especially if it is overloaded or running at a high speed. The following is a quick method of bringing the box and journal to a perfect bearing:

Leave the top cap of the box off, run the journal up to speed without load, keep a small amount of oil running on the journal, and with a cake of sapolio held on the journal it will be but a short time before there is a good bearing.

When the journal shows bright the whole length of the box the sapolio has done its work, and then with the journal running, slush out with plenty of oil and the bearing will be found to run cool when the load is put on. I have seen this method used on engine journals up to 3,500 h.p. with the best of results.
—*Practical Engineer.*

FOR THE LABORATORY

EXPERIMENTAL HIGH-FREQUENCY APPARATUS—Part IV

STANLEY CURTIS

In the present article the author will diverge somewhat from the general order of contributions appearing in this magazine. Broadly speaking, it has been the aim of most of the authors to present constructional articles in such form that practically no calculation was necessary on the part of the reader to enable him to build the apparatus described. With the development of electrical knowledge among readers of late, as evinced by the queries sent in to the Question and Answer Department, the author feels that the plan embodied in this article may be acceptable to many.

The aim will be to present the essential features of transformer design and calculation in such form as will be readily understood by the average reader. The scarcity of non-technical literature on this subject is surprising when one stops to consider the demand for it. In all of the excellent works on wireless telegraphy which have appeared in recent years, with the possible exception of one very complete volume, this subject has received no consideration whatever.

While the method of calculation given here may not hold strictly true for a resonance transformer of the highest grade and efficiency, still the design will be correct as applied to power transformer calculation with such modifications as may be advantageously employed to reduce weight and cost and to improve the insulation. The design of a resonance transformer introduces too many complications to permit an intelligible exposition to be made to strictly non-technical readers and it is therefore felt that the form here presented will prove the more useful to the majority of readers.

The resonance transformer is so designed as to produce a condition of resonance between primary and secondary circuits when a suitable condenser capacity is used. One object in transformers of this type is to reduce to a minimum or to eliminate entirely the arcing across the spark-gap immediately following the discharge of the condenser. The well-known Type E transformer is probably the best example of resonance transformer construction at the present day. This instrument represents the highest type of engineering skill, and it is needless to say that, in its development, many years of patient research were expended. The distinctive feature of this transformer, *i.e.*, the "magnetic leakage gap," has enabled the builders to obtain a patent on the transformer, therefore its manufacture or sale except under license from the patentees is prohibited.

In the ordinary power transformer when used for charging a condenser, the tendency to arc is overcome or at least greatly reduced by the insertion of a suitable impedance coil in series with the primary and the line. Other very effective methods for wiping out the arc are the rotary gap, magnetic blowout and the air blast between electrodes of the gap. These precautions are scarcely necessary on very small transformers, but where the size increases to 1 kw. or more, some means of clearing the gap should be employed.

The transformer here described is of ½ kw. capacity, and it may be used without any device to blow out the arc, providing the period of operation is not too long continued. Excellent results are obtained with this transformer when used in connection with the high-frequency apparatus described in former articles.

DESIGN AND CALCULATION

The first determinations to arrive at are the desired efficiency of the transformer, its secondary and primary voltages and its output when used on a given frequency. These factors being known, the input can be calculated as follows:

Input = Output ÷ per cent Efficiency.

For our transformer we will assume an efficiency of 94 per cent, and we know the output desired is ½ kw. or 500 watts. From this it follows that the input to secure an output of 500 watts must be

$\frac{500}{.94}$ or 531.91 watts input at an efficiency of 94 per cent.

The next calculation will be the determination of the core volume. It might be well to state here that this calculation is based upon a core constructed of the best grade of transformer iron, which can now be obtained from advertisers in this magazine. The author does not mean to say that the core must necessarily be made of such iron, but if the efficiency is desired and satisfactory operation is essential, the iron in the core must be of the proper quality.

The first step in the calculation of the core is to find the watts loss. As the input is 531.91 watts and the output is 500 watts, the loss must be 531.91 − 500 or 31.91, which is the total number of watts lost in the transformer. The losses are divided between the I^2R losses, which are caused by the heating effects of the current in both primary and secondary, and the core losses which are caused by hysteresis and eddy currents in the core. We are at present concerned with the core losses which constitute about 47 per cent of the total loss in the transformer.

We therefore take 47 per cent of the total, or 31.91, which gives us 15.5277 watts core loss. The eddy current loss will be approximately 20 per cent of the total core loss, leaving 80 per cent for the hysteresis loss. The quality of the iron plays an important part in the hysteresis loss. To get the hysteresis loss we take 80 per cent of the core loss of 15.5277 or 12.422+ watts hysteresis loss.

The allowable density per square inch at 60 cycles is 30,000, and the watts loss per cubic inch at 60 cycles is .15. The density per square inch at 125 cycles is 20,000 lines, and the watts loss per cubic inch at 125 cycles is .078. As the frequency in general use is 60 cycles our design will be made to conform with this. The density and loss at 125 cycles are given for the benefit of those who may wish to design for that frequency.

To calculate the core volume we must first determine the loss per cubic inch at 60 cycles which from the last paragraph we know to be .15. If there is a loss of .15 watts in every cubic inch at this frequency, we must therefore make our core large enough to take care of 12.422 watts hysteresis loss. The core volume then becomes equal to

$\frac{12.422}{.15}$ or 82.8 cu. in. of core volume.

The core dimensions are the next consideration, and it is difficult to lay down any set rule for their determination. The winding space must be long enough to accommodate the secondary winding with sufficient room for insulation and at the same time the length of the magnetic circuit must be kept down to reasonable proportions to lessen the reluctance. The cross section of the core has a direct bearing upon the number of turns which must be used in the primary, and it is desirable to keep this number of turns down as low as is practicable in order to lessen the number of secondary turns required to secure a given secondary voltage.

For our instrument a core of 1¾ x 1¾ in. is very suitable. This allows a core of good proportions, as shown in the drawing, Fig. 14. If the outside dimensions are made 9 x 7½ in. over all, the core will contain 79.625 cu. in., which is near enough to the designed number, 82.8 cu. in., to answer our purpose. The reader should understand that the core dimensions here given are not arbitrary, and they could be changed for others if such proved to be more convenient; the principal requisite is that the number of cubic inches of volume be kept near the designed number, or 82.8.

To determine the weight of the core, we may multiply 79.625 by .268, or the

Core of transformer iron

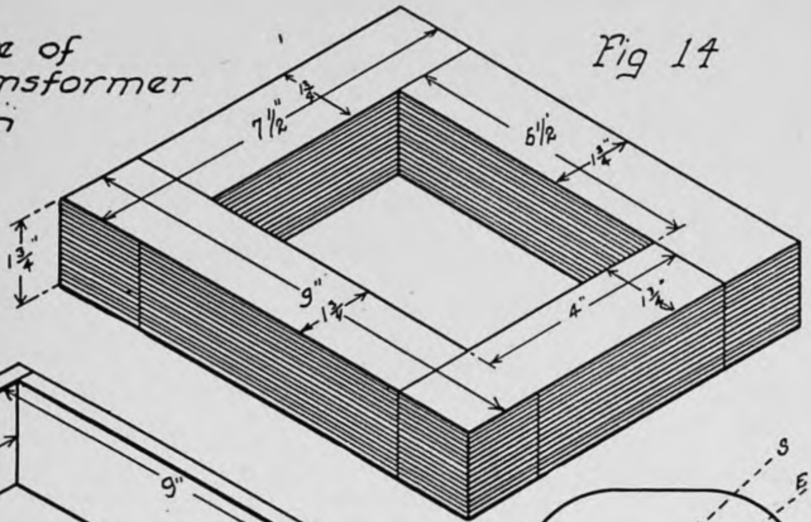


Fig 14

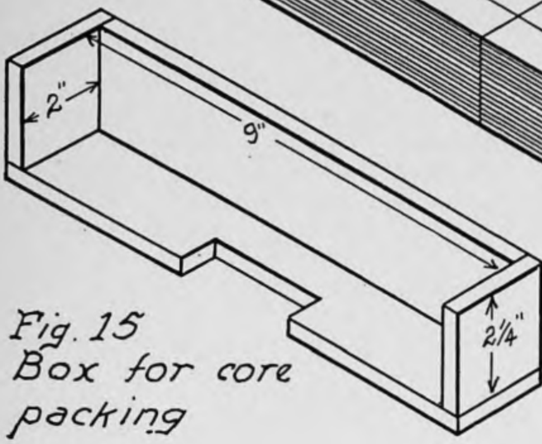


Fig. 15 Box for core packing

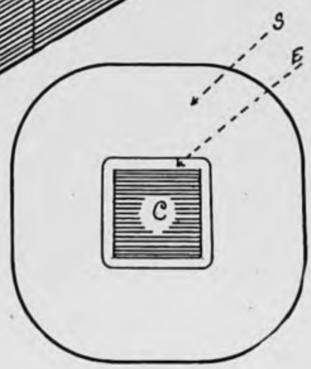


Fig 20 - C = core
S = section of wire
E = empire cloth

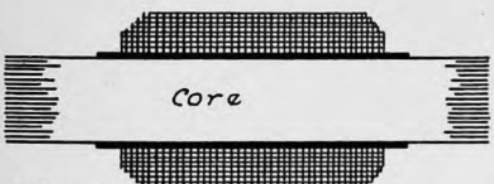
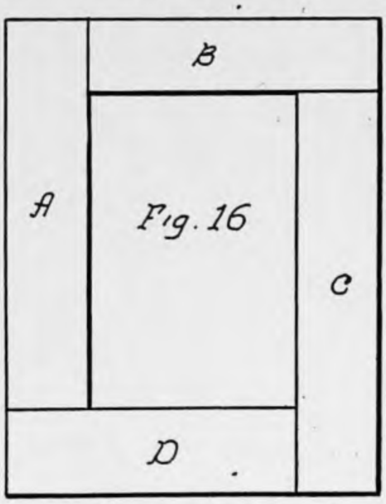


Fig. 17 Primary on core

Fig. 18 Assembly of leg

Fig. 19 Alternative method



Core assembly

Stanley Curtis 1911

number of pounds per cubic inch of transformer iron, and the product will be 21.33, or the weight of the core in pounds.

The next calculation is the determination of secondary current as follows:
Secondary watts ÷ secondary volts = secondary amperes.

Allowing 1,000 circular mils per ampere density of the secondary conductor, the area in circular mils of the secondary wire becomes:
Amperes x 1,000 = circular mils of conductor.

Applying the first formula, we have

$$\frac{500}{10{,}000}$$

or .05 amperes in secondary conductor, if a secondary voltage of 10,000 is used. To determine the size of the secondary wire we then apply the second formula:
1,000 x .05, or 50 circular mils.

Referring to a wire table giving area of various wires in circular mils, we find that No. 33 wire has an area of 50.13 circular mils. This size is, therefore, just right for our secondary conductor.

The next calculation is primary current as follows:
Primary watts ÷ primary volts equals primary amperes.

Our input in watts we have found to be 531.91, and we shall probably want to use the standard line voltage of 110 on our transformer. The primary amperes, therefore, are:

$$\frac{531.91}{110}$$

or 4.83 amperes primary current.

As we should figure on a slight overload we may take the primary current to be 5 amperes. Applying the formula for the determination of the circular mils of conductor we have:
1,000 x 5 or 5,000 circular mils of primary conductor.

The wiring table tells us that No. 13 wire has an area of 5178.4 circular mils, and it is therefore sufficiently large for our purpose. It might be well to state here that in the best makes of transformers, a density of 2,000 circular mils per ampere is allowed, so that they may be run for long continued periods of operation without an appreciable rise in temperature. It is optional with the builder whether or not he uses the larger wire, although if the overload capacity is desired, the heavier conductor should certainly be used. The use of such wire necessarily increases the weight and cost of the transformer, and if it is not to be used for more than an hour or two at a time, the standard of 1,000 circular mils per ampere will be ample.

Our next consideration will be primary and secondary turns as follows:
The total flux equals density multiplied by area in square inches.
The e.m.f. generated in the primary is

$$Ep = \frac{4.44\ N\ Tp\ n}{10^8} \text{ where}$$

N = maximum flux
Tp = primary turns
n = frequency
Ep = impressed primary voltage, hence

$$Tp = \frac{\text{Primary voltage x } 10^8}{4.44 \text{ x } N \text{ x } n}$$

Applying this formula, we have:
Maximum flux equals (1¾ x 1¾) x 30,000 or 91875. Primary voltage is 110, therefore:

$$\frac{110 \text{ x } 100{,}000{,}000}{4.44 \text{ x } 918{,}750 \text{ x } 60} = 410+, \text{ or } 410 \text{ turns}$$

in the primary.
The turns in secondary equal

$$Tp \text{ x } \frac{Es}{Ep}$$

Es being secondary voltage, and Ep primary voltage.
Our secondary turns are therefore equal to

$$410 \text{ x } \frac{10{,}000}{110} \text{ or } 37{,}272.$$

The space for the primary winding is 5½ in. in length. We should allow at least ½ in. at either end for insulation, making the space 4½ in. No. 13 double cotton-covered wire winds 11.88 turns per inch, therefore, we can get 53.46 or practically 54 turns per layer without encroaching on the space at either end. As it is desirable to bring out taps at various places in the primary in order to increase the voltage of the transformer by cutting down on the turns, we had better wind the first four layers with 54 turns each, and the remaining four with two less turns in each, as suggested in Fig. 17, making in all 412 turns.

The method of holding the end turns was described in the last article. To determine the amount of wire required to wind the primary, we first determine the average length of the turns. Allowing 1/8 in. for insulation on the core, we take the distance around all four sides which is 4 x (1¾ + ¼) or 8 in. This is the length of the shortest turns. The winding will be approximately ¾ in. deep, including the insulation and bulging of the wire, therefore the longest turns will be 4 x (1¾ + 1½) or 13 in. If we now take the sum of 8 and 13 and divide this by two we get 10½, or say 11 in., for the average length of turns. There are in all 412 turns in the primary, therefore there are 412 x 11 or 4,532 in., or 377¾ ft., of wire in the primary winding. As No. 13 d.c.c. wire runs about 63 ft. to the pound, there will be 377¾ or say 380÷63 or 6, and a very small fraction pounds of wire required. Experience has proven that 6 lbs. are ample for this winding.

The secondary should be wound in sections, particularly if cotton-covered wire is used. With enameled wire the layer winding gives very good results, but it is essential that a layer of empire cloth be used between each layer of wire and its neighbor.

The dimensions of sections and the weight of cotton-covered wire will first be considered. If the wire were wound perfectly by machine there would be 7,290 turns per square inch of No. 33 s.c.c. The average amateur winder will lose about 20 per cent of this number of turns through rapid and uneven winding, therefore we can safely depend upon 5,832 turns per square inch of winding space. As we require 37,272 turns in all in our secondary it is evident that we must have 37,272÷5,832 or 6.39+ sq. in. of winding space in the secondary bobbin. Allowing for the swelling of the insulation from the wax, we should say 6½ sq. in. The maximum allowable thickness of section is ¼ in. To this we add 1/16 in. for the disc of empire cloth of several thicknesses between each section and the adjacent one. As the winding space is 4½ in. in length, allowing ½ in. for insulation at ends of secondary bobbin, we must have 4½÷(¼ + 1/16) or 14+ sections. We have 6½ sq. in. of winding space to be distributed among 14 sections, each not more than ¼ in. thick. Therefore, each section must furnish .46 or practically ½ sq. in. of winding space. As the thickness of the section is ¼ in. it is apparent that we must make the sections 2 in. deep in order to provide ½ sq. in. of space in each.

Now to prove that our design for the dimensions of the core is correct, let us see how much space is left between primary and secondary when they are in their respective places on the core. The primary takes up ¾ in. of the space inside the core and the secondary takes up 2 in. + ¼ in. insulation + a possible ¼ in. for curvature of the outside turns, or 2½ in. in all. Therefore, there will be a space of 2½ in. + ¾ in., or 3¼ in. in all, taken up by windings and insulation. This subtracted from the 4 in. of space between legs of core leaves ¾ in. of space between primary and secondary coils. This is ample if the coils are further insulated from each other by a block of empire cloth, hard rubber or micanite placed in the space. This proves that sufficient space has been left, even though cotton-covered wire has been used.

The use of enameled wire is strongly advised as the same number of turns, or a much greater number, for that matter, may be placed in a smaller space, and a higher voltage secured without inordinately increasing the resistance of the winding.

To find the weight of the secondary wire we take the average length of turns as in the case of the primary. To each side of the core we add ¼ in. for insulation, thus giving each side of the enlarged square a length of 2¼ in. The length of the shortest turns is, therefore, 4 x 2¼ or 9 in. The length of the outside or longest turns will be (2¼ + 2 + 2) x 4 or 25 in. The average length of turn is, therefore, 17 in. As there are 37,272 turns in all, there will be 633,624 in., or 52,802 ft. of wire in secondary. As there are approximately 6,591 ft. per pound of No. 33 s.c.c. wire, we shall require 52,802÷6,591 or 8.01 lbs. To allow for waste and the cotton covering we should provide about 8½ lbs. of wire.

TRANSFORMER CONSTRUCTION

So much has been written on the subject of high-tension apparatus and its construction that very little need be said here. The drawings show the construction quite clearly, and for details the reader is referred to the many articles on this subject which have appeared in previous issues.

A few hints regarding the building up of the core may not be amiss, however, and the reader is requested to note Fig. 16. The iron for the core is cut into strips 7¼ in. in length by 1¾ in. in width for the two sides of the core. A pile 1¾ in. high will be required for *each* side. The end pieces are cut to the same width but only 5¼ in. in length. The same number of pieces are required for the ends as for the sides. The sides are assembled first in a box similar to that shown in Fig. 15, pieces being placed alternately as shown in Fig. 18. When both sides have been built up they may be taped with one layer of friction tape. By clamping the pieces in the vise and releasing only a small portion at a time as the taping proceeds, the builder will be enabled to produce an extremely compact bundle of laminated iron. The leg on which the primary is to go is to be covered with empire cloth to a thickness of ⅛ in. before winding primary. The secondary leg must have a thickness of at least ¼ in. of the cloth, to afford good insulation. After primary and secondary are in place on the core the end pieces may be inserted.

The author has frequently read directions for building cores of this kind, wherein the writer advised the builder to make up the four sides of the core into bundles tightly taped and "after placing the windings in position, slip the ends of the core into place." It is a simple matter to place the individual pieces of the ends into position, but if any builder can make the *assembled* end fit into the sides or legs which have also been assembled and taped, the author would appreciate the receipt of the formula. This "stunt" is all the more difficult when one takes into consideration the fact that transformer iron is but fourteen thousandths of an inch in thickness.

The one practicable method of so building up the core is to use the scheme illustrated in Fig. 19. In this method, several sheets are used for each alternation instead of but one sheet. The only advantage which can be claimed for such construction is the quickness in assembling the core.

The assembled core will resemble Fig. 16 when looking down on it. The preceding layer of iron would be "staggered," *i.e.*, *A* would overlap on *D*, *B* on *A*, *C* on *B* and *D* on *C*.

Fig. 20 gives an idea of the proportions of a secondary section to the core and insulation.

Figs. 21 and 22 show secondary side elevation and plan respectively of the completed and mounted transformer. The terminal pillars of the secondary are of fiber and are wound with inductance coils as suggested in the article in the August issue for the open-core transformer.

The four taps from the primary winding are brought out to the four binding posts 8, 7, 6 and 5 on the connection strip, as suggested in Fig. 22. The starting end of the coil is connected to 1 on the strip. By cutting out layers in the primary, the secondary voltage will be increased, but if less than the full number of turns is used an impedance coil should be connected in series with the primary and line to control the current. If the full number of turns is used, the primary terminals may be connected directly across the 110 volt mains.

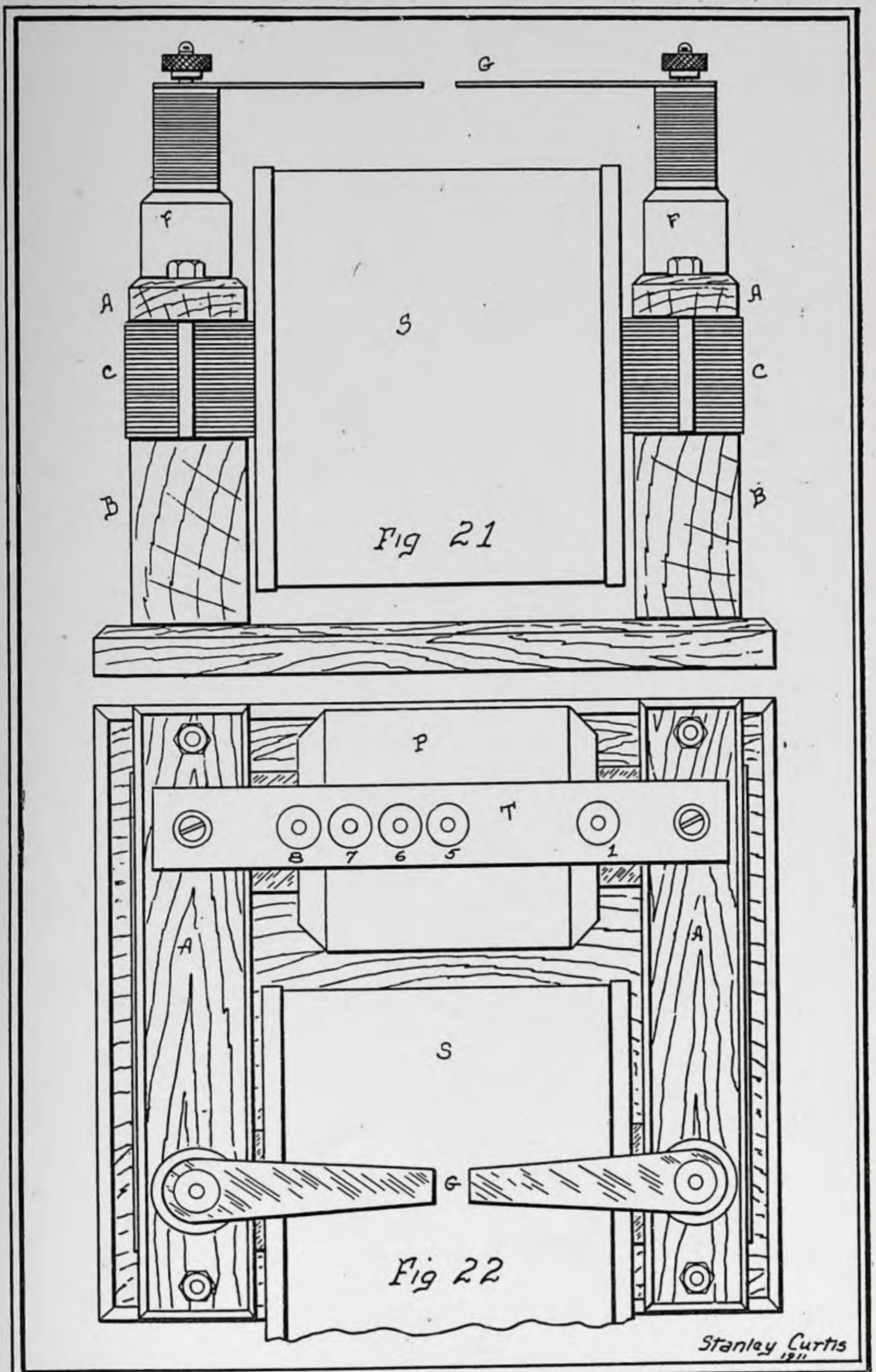
The mounting is preferably as shown, although, if oil insulation may be conveniently used (where weight is no disadvantage) the whole transformer may be placed in a tank or box which is filled with transil oil. This affords the best possible insulation.

The next article will take up the construction of suitable impedance coils and various forms of spark gaps.

Imagination precedes and is the cause of all achievement.

Be good natured until about ten in the morning and the rest of the day will take care of itself.

A character is a man who knows what he wants; who does not allow his temper and moods to govern him, but acts on firm principles.—Treu.


G
F
F
A
A
S
C
C
B
B
Fig 21
P
T
8
7
6
5
1
A
A
S
G
Fig 22
Stanley Curtis
1911

SURFACING THE POLE PIECES OF TELEPHONE RECEIVERS

H. P. CLAUSEN

After a telephone receiver has been completed to the point where it is ready for having the pole pieces surfaced parallel with the surface of the shell upon which the diaphragm rests, it becomes necessary to provide an arrangement which permits of so grinding the pole pieces that they will be parallel with the surface of the shell and anywhere from five to ten thousandths of an inch below the surface of the shell.

One method much used consists in an arrangement as shown by Fig. 1, in which an emery wheel *W*, driven at a suitable speed, is mounted below a movable table *T*, having a slot *S* immediately over the grinding surface of the emery wheel, and so arranged that by means of the screw *A*, the table *T* can be adjusted upward or downward in fractions of thousandths of an inch. The upper surface of the table contains a receptacle *R*, in which the receiver shell fits, and made so that it will slide back and forth between the parallel bar P^1 and P^2. After the table has been properly adjusted to the receiver, the receiver cup, together with the magnet coils mounted in place, is set in the receptacle and, while moving forward and backward, the receiver is also rotated so that the emery wheel may properly surface off the receiver magnet pole pieces.

This method, while it has been pretty universally applied, is in some instances not as satisfactory as that shown by Fig. 2. Here we have an arrangement in which the collar *C* is screwed fast to the body *B*, and held in a locked position by the knurled collar *L*. *M* represents an end milling cutter, placed into the body of the receptacle *B* and locked securely into position. It will now be observed that when we mount the entire tool in the chuck of the lathe, the receiver, together with its pole pieces to be ground down, may be pressed against the end as shown, with the result that the steel cutter *M* cuts away the surplus iron of the pole pieces in a circular manner. It is noted that with the collar *C* adjusted in the proper position, the distance of the surface to

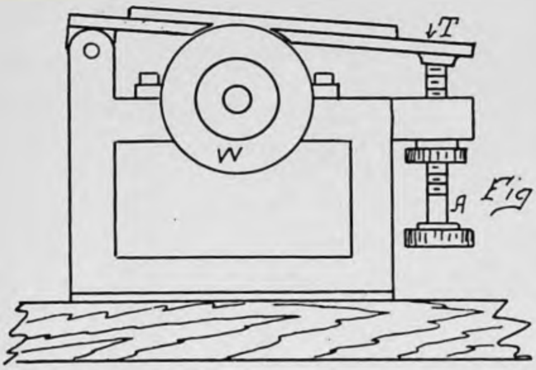
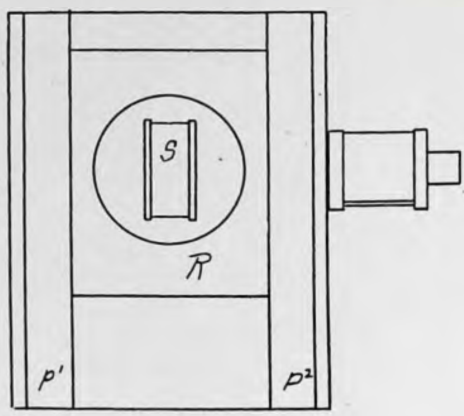


Fig 1



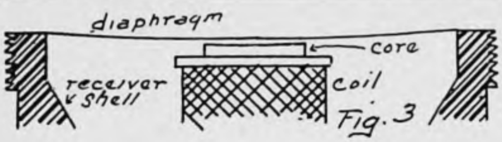


Fig. 3

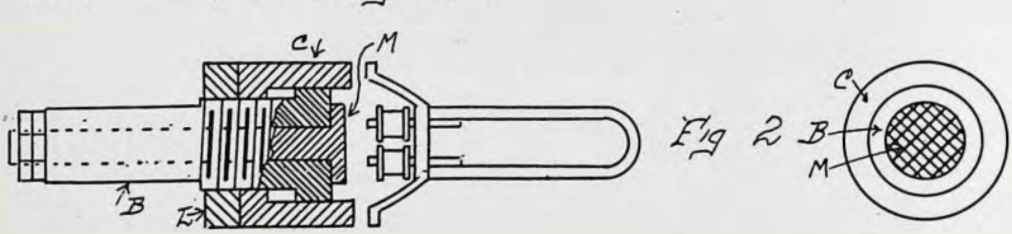


Fig 2

which the receiver magnets are ground may be easily maintained. One advantage of this circular cutting arrangement consists in thus providing a means for permitting the depth to be less towards the center than at the outer periphery, for, as shown in an exaggerated manner by Fig. 3, when the receiver diaphragm draws downward, the center of the diaphragm is somewhat lower than the outer edges. Therefore, if we grind the pole pieces of the receiver to conform somewhat to the position of the diaphragm surface, we obtain a noticeable increase in efficiency of the receiver, particularly when the receiver is of the type in which no permanent magnets are employed, for, with such receivers, the closer we can adjust the diaphragm to the pole pieces, the better the results.

When manufacturing receivers containing permanent magnets, it is sometimes impossible to thoroughly magnetize the receivers after assembling. It, therefore, becomes necessary to grind the receiver after the magnets have been saturated with magnetism. As it is well known that any jarring or hammering effect upon the permanent magnet tends to reduce its residual magnetism, the method shown by Fig. 2 is productive of more satisfactory results than that shown by Fig. 1. In one case we have the emery wheel running at a high rate of speed striking the receiver magnets and jarring it considerably, whereas in the plan shown by Fig. 2, the pounding effect is not nearly so serious.

National Effort to Reduce Railroad Casualty Record

A national effort to reduce the loss of life in railroad operation in the United States by seeking statutes to prohibit trespass on rights of way, a major cause for casualties, also the enlistment of officials and employes in a systematic war on accidents and also the adoption of safeguards has been announced by the League for Public Safety, the headquarters of which are to be in Chicago.

According to the last bulletin of the League for Public Safety, the efforts will be along well defined and constructive lines.

"About half of those persons killed and injured in railway accidents in the United States were making a thoroughfare of dangerous ground—some railway right-of-way," that bulletin declares. "In most states no laws prohibit trespass—children and others who do not know the hazard may go into that danger and do and are killed because no one is empowered to stop them. In this, railroads are not to blame.

"Again, there is no systematized effort a-foot to arouse railroad employes as a whole to the greater care and obedience. That this is needed is shown by the results of doing it and the experience of every railway official. The plan of 'committees of safety' on each division, made up of men from the track, roundhouse, train and supervising forces, is a proven success. The men get a feeling of shared responsibility. The pension system is also advocated to keep men from shifting from job to job.

"Greater obedience must start in the homes.

"Signal safeguards must be more generally adopted. Only 65 per cent. of the steam railway and practically none of the electric interurban mileage is protected. The investments are found to be repaid in one to five years by the saving of wreck losses."

The Relative Cost of Drilling

(Concluded from page 164)

drill comes out perfectly sharpened and hardened for instant use. The economical and efficient handling of the drills by machinery saves thousands of dollars to the company. An electrical counter is also a part of the plant equipment which records accurately the number of drills handled each day. While some 3,000 drills are sharpened a day in this plant the capacity can be about doubled in emergencies.

But here gain very much depends on the nature of the material through which one is cutting. In copper mining a drill used night and day for a year is pretty well used up, and in many cases it pays to throw it away. The drill repairs in copper mining average probably 30 cents per drill per ten-hour day. This is a moderate cost, and probably would be increased in some mines.

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.

1653. **Induction Motor.** F. D. H., Wymore, Neb., proposes to rewind a motor that has been burned out. It is of the General Electric Company's make, having stator punchings 5¼ in. outside diameter and 2⅞ in. inside. Rotor is of the squirrel-cage type, 1⅝ in. long and 2¾ in. in diameter. Stator has 24 slots, wound for four poles and adapted for use on a 110-volt 60-cycle circuit. There are three coils per pole in the main winding, each consisting of 100 turns. The inmost coil embraces but one tooth; the next, overlapping it, embraces three teeth, while the third, or outer coil, embraces five teeth. Similar windings are on the other three groups of teeth, but the connections of alternate groups are in reverse order for the purpose of giving the correct polarities. In addition to this main winding, there is an auxiliary winding of four coils, each having 110 turns, occupying the partially filled central slots belonging to the main winding, but lapping half way onto the latter, thus making a two-phase arrangement. Each of the "starting" coils embraces five teeth. The writer asks for directions for rewinding the motor so as to get the greatest possible amount of power. Ans.—Your description and sketch is, in the main, fairly clear. Still we would have been able to locate the exact winding if you had given us the data recorded on the name plate on the motor. Evidently it is one of the "Small Power" motors, adapted for such purposes as running sewing machines. As you have made no mention of any external starting device, we suppose it has none, and the motor was put into use by merely closing a switch. In this case, the starting winding that is to be connected in parallel with the main winding should be automatically opened as soon as a moderate speed is attained. This is often attained by means of a centrifugal device. If your motor still has the burned-out coils, you may rest assured that you can do no better than to use identical sizes of wire. The manufacturers, under the spur of the close competition that now exists, can be trusted to have gotten the most out of the machine. The use of enameled wire would undoubtedly be an advantage, for the motor would then endure a greater heat. We think you have only approximately measured the difference between rotor diameter and stator bore, for the clearance is often only 1/64 in. You will find interesting descriptions of the pioneer windings of this sort of self-starting single phase motor if you will look up the "Heyland" machine.

1654. **Resistance.** W. M. B., Washington, Pa., asks: (1) What sort of a resistance to use when charging 6-volt ignition batteries from a mercury-arc rectifier set that gives a minimum of 45 to 50 volts? (2) Is there any flux that is helpful when burning lead joints of storage batteries? (3) How may a 50-volt 16,000-alternation fan motor be run from a 110-volt 60 to 125-cycle circuit? Ans.—(1) There are so many possibilities in solving this simple problem that we can suggest only a few. In any case you should have an ammeter in circuit with the cells, and charge at say 1.5 to 2 amperes rate. You can put two rows of porcelain knobs on the wall, and loop bare German silver or iron wire, say No. 24, back and forth, until by trial you have enough resistance to hold the current to the desired value. A bank of six or eight 110-volt incandescent lamps will also make an admirable rheostat. Use key receptacles for holding them, and of the two parallel wires between which they are connected, one is attached to the rectifier, the other to the battery. By turning on or off the lamps you can get any desired current. Of course the lamps will burn only red. (2) With carefully cleaned surfaces you need no flux at all, but resin, or plumber's "candle," works well. (3) 16,000 alternations per minute and 133 cycles per second mean the same thing, and 125 cycles is usually regarded as equivalent. A rate of 60 cycles cannot be put in the same class, and your motor will not run on such extremes of frequency. About the best way to allow for use of the higher frequencies will be to put a reactive coil, such as is used in multiple alternating current arc lamps, in series with the motor. By trying the successive taps that connect with the winding of the coil, you can adjust the reactance to fit the motor. At 60 cycles the motor will run at only half speed, and unless you increase the amount of reactance you run the risk of burning out the winding. At present yours is an 8-pole motor. For 60 cycles it should have but 4 poles.

1655. **Remagnetizing.** E. K., Winchester, Ohio, asks: (1) How may permanent magnets be re-energized? (2) Where can German silver wire be obtained? (3) Can a strong enough electric motor be built for use on a bicycle and operated by dry batteries? Ans.—(1) Bridge them across the poles of a powerful electromagnet. For this purpose the field magnet of a small dynamo,—separately excited from some suitable source,—may be used. (2) Any city dealer in copper magnet wire should also carry German silver in stock. Address any dealer in Cleveland or Cincinnati. (3) No.

1656. **Moving Picture Arc Transformer.** A. B. C., Chicopee, Mass., asks: (1) For the design and specifications of a transformer to be used in connection with a motion-picture arc. (2) For formulas for the design and calculation of choke coils and a step-down transformer to give from 10 to 30 amperes at secondary. Ans.—(1) Your request is for the design of a 2 kw. power transformer in which is incorporated the necessary regulating devices for control of the current. To give the formulas and calculations necessary would be beyond the scope of this department, and we can do no better than refer you to one of our advertisers whose announcement appears in the "classified" columns and from whom you may obtain the specifications you desire. (2) While space will not permit us to publish the formulas, we might suggest that you refer to the January, 1911, issue for data on small transformer. If you use the same weight of No. 14 wire in place of No. 16 and connect the secondaries in parallel, you may take a current of 30 amperes at about 8 volts for short periods of time.

1657. **Black Printing Paper.** P. M., Jamaica, N.Y., asks for a formula for making black printing paper. Ans.—The formula for this paper is as follows, although we cannot recommend it as a particularly satisfactory process, as it is difficult to keep the whites clear: Procure a piece of well-sized paper and sensitize with the following preparation: gelatin, 1 part; perchloride of iron, 2 parts; tartaric acid, 1 part; persulphate of iron, 1 part; water, 30 parts.

1658. **Fireproofing Wood.** G. S. C., Arlington, Mass., desires a formula for an inexpensive solution for fireproofing wood. Ans.—For application with the brush the following compositions are the best: apply hot, sodium silicate, 100 parts; Spanish white, 50 parts; glue, 100 parts. Apply successively and hot; for first application, water, 100 parts; aluminum sulphate, 20 parts; second application, water, 100 parts; liquid sodium silicate, 50 parts. First application, two coats, hot; water, 100 parts; sodium silicate, 50 parts; second application, two coatings, boiling water, 75 parts; gelatin, white, 200 parts; work up with asbestos, 50 parts; borax, 30 parts; and boracic acid, 10 parts. Oil paints rendered uninflammable by the addition of phosphate of ammonia and borax in the form of impalpable powders incorporated in the mass, mortar of plaster and asbestos and asbestos paint are still employed for preserving temporarily from limited exposure to a fire. The following is also a very effective treatment. Subject the wood or wooden objects for six to eight hours to the boiling heat of a solution of 33 parts of manganese chloride, 20 parts of orthophosphoric acid, 12 parts of magnesium carbonate, 10 parts of boracic acid, and 25 parts of ammonium chloride in 1,000 parts of water. The wood thus treated is said to be perfectly incombustible even at great heat, and besides, to be also protected by this method against decay, injury by insects and putrefaction.

1659. **Wireless Queries.** L. F. M., Philadelphia, Pa., asks: (1) Why the variable condenser is shunted across the secondary of a loose coupler. (2) How it is possible to receive waves from an aerial of smaller capacity than your own; if in series with ground, a variable condenser will remedy this. (3) How the current capacity of a high potential transformer may be varied besides having taps in primary. Ans.—(1) This is not necessary, but is used to get a slightly better resonance effect between the primary and secondary of the oscillation transformer. (2) The wave-length of any oscillator is dependent on the square root of the product of the inductance and capacity of the oscillator. Hence, two aerials may have the same wave-length, but one may have a lower capacity and a higher inductance than the other, in such values that the products of the quantities in each antenna balance. Thus, by using an adjustable inductance or an adjustable capacity, you can lengthen or shorten the wave-length of your antenna to coincide with that of an antenna of a different value. (3) By inserting a reactance coil in series with the primary winding.

1660. **Wireless Receiving; Spark Coil Data.** M. E., Brooklyn, N.Y., asks: (1) If diagram of connections he sends us is correct. (2) His receiving radius with instruments he mentions. (3) Data for ½ in. spark coil. Ans.—(1) No, you should place a fixed condenser in series with the detector. The telephone receivers can be bridged around the condenser. (2) From 500 to 900 miles. (3) Core, 1 x 11 in. annealed No. 22 B.W.G. iron wire; primary, 3 layers No. 16 B.&S.G. d.c.c. magnet wire; insulating tube, micanite, 1¼ in. I.D., 12 in. long, ⅛ in. wall; secondary 4 lbs. No. 30 enameled magnet wire, wound in sections, 2¼ in. I.D., 3½ in. O.D., and ⅛ in. thick.

1661. **Wireless Transformer.** J. P. F., Ft. Wm. H. Harrison, Mont., writes us that, when he connects his silicon detector in shunt with the telephone receivers without making any connection with aerial or ground, he can get the sound of the testing buzzer quite plainly at all times. (1) He wishes to know what this indicates. (2) He proposes to build a combination transformer in which both the open and closed magnetic circuit cores may be used interchangeably and asks our opinion on the arrangement. Ans.—(1) Apropos of the silicon detector, we would say that it is not always the loudest buzzer sound that indicates the most sensitive point of adjustment. The way you have your receiving set hooked up probably throws it in resonance with the buzzer circuit which has a very short wave-length, thus bringing the noise in at its maximum. You will also sometimes find, when using the tuning coil, that you can nearly cut out the buzzer by changing the coupling, or putting in a large amount of inductance. This is right, as the buzzer is merely a small transmitting outfit, and if your set is tuned properly you should be able to tune out the buzzer. (2) Your method of building the core of your coil would be very unsatisfactory, especially if you changed your windings often, as the constant bending of the iron would not only wear away the oxide formed by the annealing, which prevents eddy currents to a certain extent, but would in a short time break the iron along this point. We advise you to build the core as described in the June and July, 1909, issues of this magazine in article by Mr. W. C. Getz, on the construction of a closed core transformer. In addition to this, you would require about twice as much primary wire as you specify, to have the necessary impedance to work on 110 volt circuit. Would advise you to either make your transformer entirely open core or closed core, as the designs of the types differ so radically that no combination affair would give you any efficiency.

1662. **High-Power Wireless Equipment.** L. H. M., Mexico, asks for suggestions on the equipment of a wireless station to cover a distance of 700 miles air line. Ans.—You would require at least a 5 kw. transmitting outfit. Storage batteries would be impracticable. We would advise that your concern install a gasoline engine and generator set, to furnish the power. We would advise a plant having an 8 h.p. gasoline engine, and a 120 cycle 5 kw. 110 volt a.c. generator. A power board containing the field rheostat of the d.c. exciter, (furnished usually with generator) a voltmeter and an ammeter, together with a circuit breaker and the necessary switches would also be required. We would suggest that you get into communication with some reliable wireless engineer, and consult with him before your firm invests in the equipment, so that there may be no loss through buying the wrong equipment. If desired, we will refer you to one.

BOOK REVIEWS

Electricity in Locomotion. An account of its mechanism, its achievements, and its prospects. By A. G. Whyte. New York, G. P. Putnam & Sons, 1911. Price, 40 cents net.

This monograph, one of the Cambridge Manuals of Science and Literature, describes the part which electricity has taken in the development of locomotion, primarily from the English standpoint. The progress of electric railways in that country has been quite different from and much less thorough than in the United States, and the consequence is that trolley omnibusses and storage battery cars and busses have received much more development than in this country, where trolley cars are practically the only means of electric traction in use in and between our cities and towns. The book is consequently broader in scope than one on American conditions would be, and consequently more useful as giving an idea of the possibilities of the field.

Aerial Locomotion. By E. H. Harper, M.A. and Allan Ferguson, B.Sc. New York, G. P. Putnam & Sons, 1911. Price, 40 cents net.

This is another Cambridge Manual which attempts to give within the short compass of 160 pages, a connected statement of the principles underlying aerial locomotion. The various chapters cover the general principles, propellers and motors, stability and control of aeroplanes, model aeroplanes and gliders, aeroplanes, dirigibles and the history of aerial locomotion. As a concise and carefully written summary the book has much value and interest.

Outlines of the Theory of Electromagnetism. A series of lectures delivered before the Calcutta University. By Gilbert T. Walker M.A., Sc.D., F.R.S., Director General of Observatories, India, and formerly fellow of Trinity College, Cambridge. New York, G. P. Putnam & Sons, 1911. Price, $1.00 net.

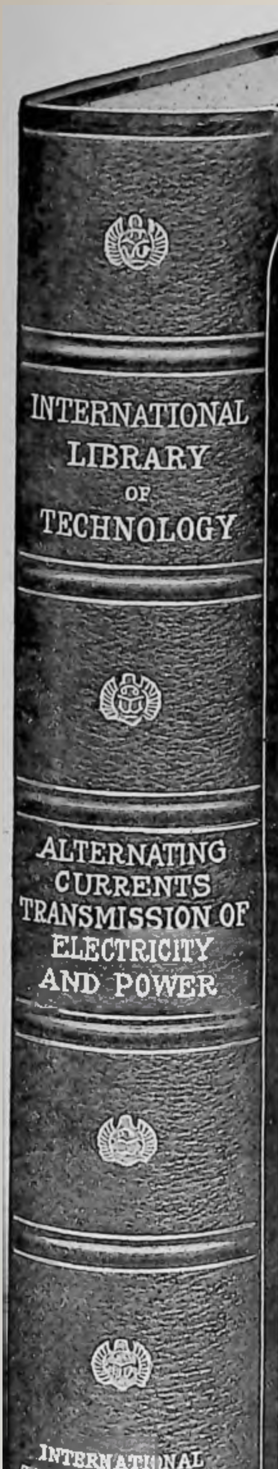
This book is an attempt, on the the part of the author, to put some of the more important developments of electromagnetic theory into a connected and convenient form for the use of college students. While the treatment is necessarily severely mathematical, the arrangement is systematic, logical and concise, and the book is a thoroughly satisfactory textbook.

The Principles of Aeroplane Construction. With calculations, formulae and 51 diagrams. By Rankin Kenedy, C.C. New York, D. Van Nostrand Co., 1911. Price, $1.50 net.

This book is intended for the practical constructor of flying machines, and starts in with a thorough consideration of the mechanical and physical principles involved in the use of planes to displace fluids. It advances to the use of the various formulae for determination of dimensions of aeroplanes and for calculating the energy constants involved in flying. Careful analyses of the various machines in use today are given, and the curves, balancing and steering, and propulsion are all carefully worked out. The author appears to believe that the helicopter may prove a practical form, and devotes a chapter to its construction. He arrives at the very obvious conclusion that the present-day aeroplane is but a passing type, and that the great problem of the inventor and engineer is the working out of a method of automatic stability.

Flying Machines Today. By William Duane Ennis, Professor of Mechanical Engineering, in the Polytechnic Institute of Brooklyn. New York, D. Van Nostrand Co., 1911. Price, $1.50 net.

This book, profusely illustrated and interestingly written, is intended more for the lay reader than for the practical aviator, and endeavors to give the average man, without any resort to mathematics, a clear idea of the manners and methods of working of the various forms of aeroplanes at present in use. In this it succeeds admirably.



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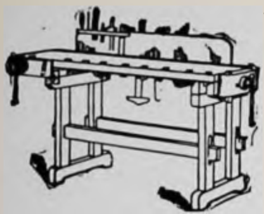

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