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Electrician and Mechanic

VOLUME XXI AUGUST, 1910 NUMBER 2

DESIGN AND CONSTRUCTION OF MODEL AEROPLANES

EXPERT

FOREWORD

In commencing this series of articles we are convinced that we are supplying a distinct want by dealing in a simple manner with this great subject, in order that many readers and workers may be given an opportunity of first intelligently grasping the theory and principles which govern aeronautics in so far as they concern Aeroplanes, and then providing them with constructional details and conduct experiments with them to enable them to produce the finest type of model Aeroplanes.

The great advance in aviation by heavier-than-air machines, has been watched with considerable interest by the general public, and it may be safely stated that no other form of conveyance has resulted in so much experimenting by means of working models.

There is an increasing number of people not only interested by the continued advance of aeroplane construction and design, but a surprising number who are making working models embodying the best points of those already made with carefully thought-out ideas of their own, resulting from their experiments. It is by these experiments that improvements will be made, and those which will help to solve the many problems now confronting the designers of aeroplanes.

There are many ambitious people who are making models from published designs, but have no idea of the scientific principles involved in the construction and flight, and more often than not, fail to get their model to fly, owing to this lack of knowledge. It is therefore evident that at least the fundamental principles should be thoroughly understood; thus, before any type of aeroplane is described, the reasons why a plane glides through the air will be first explained.

All of us have, at some period of our childhood, flown a kite, and it is to the well-known effects of kite-flying that we will look for our first lesson in aeronautics.

We know that the horizontal pressure of the wind on the inclined surface of a kite causes it to rise, and the stronger the wind, the more pull there is on the string. To further illustrate this action of the wind, reference should be made to Figs. 1 and 2. The angle at which the air meets the kite is called the angle of incidence and for all practical purposes it may be taken that the wind is deflected at the same angle. If a line T bisecting this angle ID is taken, it will give the position of the upward thrust, and the centre of pressure at P.

Now, supposing that instead of the wind blowing against a stationary surface, that surface were moved through still air, a similar upward thrust would be obtained, provided that the air so meets the surface that, after passing the angle of incidence, a downward pressure is given to it.

An aerofoil surface, then, must be so shaped to capture the air and propel it downwards. It will then glide through the air. This forms the basis of all aeroplane construction. The most suitable form of surface for an aeroplane is the result of careful experiment, with small planes placed in front of a powerful current of air, by such authorities as Mr. Horatio Phillips, Sir Hiram Maxim and Mr. José Weiss, who all arrived at practically the same result by independent means.

This form of plane is shown at Fig. 5, and by means of dotted lines the action of the air is shown, that is, of course, when the plane or aerofoil, as it is technically termed, is propelled through it. It will be seen that the undersurface of the aerofoil condenses the air and the curvature of the upper surfaces causes a partial vacuum.

The principal point we have to consider now, is the actual fact that a curved plane directs the air in a downward direction and exerts a lifting effect on the plane; or, in other words, the reaction of the air in the act of being displaced supports the plane.

The most suitable angle at which the aerofoil should meet a horizontal current of air has been determined at about 1 in 8; but with small models this angle may be finer, good results having been obtained with an angle of 1 in 15.

Many interesting experiments may be made to prove the action of air on plane and curved surfaces. Take half a sheet of writing paper and bend it as shown at Fig. 3, blow in the direction of the arrow, and notice the lifting action of the other end. Now fold over as shown at Fig. 4, about 2 in. backwards and forwards several times until the folded portion will easily move up and down, and blow again. It will be seen that the flap will lift up and remain up while the air is directed on the plane. If a current of air is directed underneath the flap will vibrate only and act as a drag on the forward lifting of the plane.

Another experiment may be made with notepaper and cardboard to show the lifting effect of the curved plane. Cut out two pieces of thin cardboard and touch the edges with glue or seccotine; fold a piece of notepaper over to form an aerofoil. Next support the plane with cotton and blow directly on the front with a pair of ordinary bellows or direct the escaping air from a toy balloon instead, and observe the lifting action.

We have seen that the curved aerofoil is most suitable, and must now consider the length and width of planes, or the aspect ratio; that is, the proportion of width or depth to length. It has been proved by experiment that a plane with a long front edge or entry and narrow depth is more efficient than one with smaller span and greater depth, and this is easily understood by glancing at Fig. 6. The air meets the long edge and is captured by the curved surface and directed downwards. A wide plane as suggested by the dotted lines would only be effective at the front portion, the rear would exert very little effect on the air which has already been deflected, and would give extra weight to no effect.

We may take it that the chief part of the actual work of supporting an aerofoil is done by the underneath portion of the plane, also that a plane with a large aspect ratio is necessary for speed and lifting power, and also that the angle of the aerofoil should be somewhere near 1 in 10.

Various mathematical calculations may be given to prove the truth of these theories, but as these involve a knowledge of trigonometry and are not really essential, they are omitted. It is a comparatively simple matter to vary the factors governing the fundamental principles of construction that abstruse mathematics may be safely left to the theorists. The principles underlying the design of aeroplanes, should now be understood and in the next article we will describe the various machines which have made successful flights.

Before commencing the design and construction of models, it will be as well to notice the lines along which the development of the modern aeroplane has run, and consider the types already proved to be conquerors of the air.

Although a considerable number of theories had been propounded and some few practical attempts had been made previously, it may be considered that the actual development of aeroplanes dates from the experiments of Otto Lilienthal, a German engineer, in the early nineties.

A lifelong study of the flight of birds led him to construct a three-pair set of wings, to be operated by his own hands and feet, the wings opening and closing like venetian blinds. He was unable to raise himself without the aid of a counterpose weight, and then, only at the expense of great muscular effort, so he soon decided that flapping flight was impracticable. His next experiments were with fixed wings, which he used as gliders, and he was so successful that he devised a double-deck arrange-

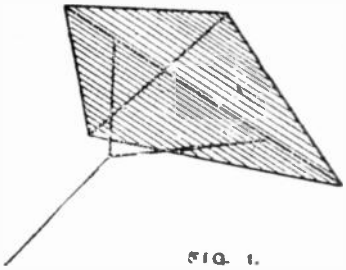


FIG. 1.

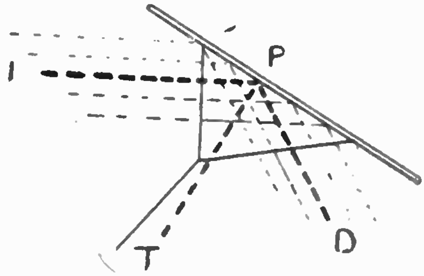


FIG. 2

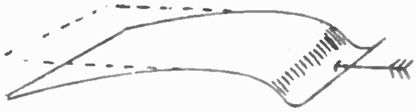


FIG. 3.

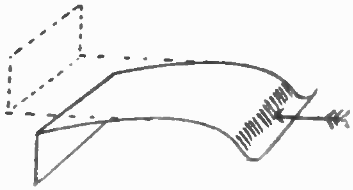


FIG. 4.

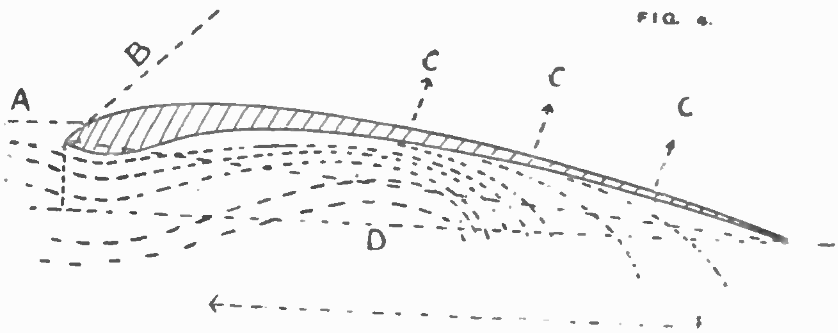


FIG. 5

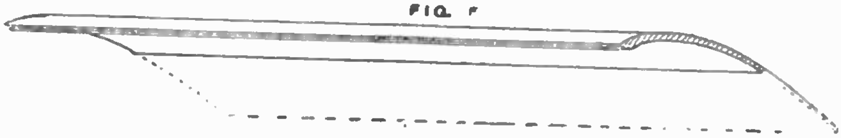


FIG. 6.

ment of wings, and was enabled to take longer glides.

FIRST GLIDING EXPERIMENTS

He was in the habit of commencing a glide from the top of a hill some 250 ft. high, and with a suitable wind could travel about 750 ft. Unfortunately, in 1896, he lost his life through encountering a current of air, which capsized his glider and precipitated him to the ground.

His valuable experiments were continued, in America by Herring, in England by Pilcher, and in France by Ferber, Pilcher losing his life a short time afterwards in a similar manner.

In America Herring and Chanute worked together, and commenced a series of experiments, which furthered the double-deck style of glider. The Wright brothers also experimented with long bi-plane gliders, and arrived at the type of aeroplane bearing their name.

The first aeroplanes to be raised and propelled by motive power were invented by Langley, in America, and Maxim, in England, about sixteen years ago. Both of these distinguished inventors had to rely on the steam engine, and the excessive weight of the engine, together with the impossibility of carrying much water, prevented them from being raised more than a few inches above the ground. Credit must be given them for their work, for had they been able to use the light petrol engine of the present day, it is impossible to say to what extent the art of flying would have developed.

The Wright brothers were the first to adapt a petrol engine to a large biplane glider, and their aeroplane, as shown in Fig. 1, page 49, is the most simple of any. The main planes, *a* and *b*, are over 40 ft. long and 6 ft. wide, the framework being built of spruce, the ribs, about thirty-two in number, being securely attached to the main timbers, which are just over 4 ft. apart.

The curvature of the planes is about 1 in 20, each side being covered with rubbered cloth. The two main planes are united by nine pairs of uprights, which are securely attached to the main timbers, with the exception of three at each rear end, which are attached by means of hooks and eyes, so that they are movable. The whole structure is braced up with wire and there is a system of wires and pulleys, by which the rear ends of the planes *c* may be warped or flexed. This method of warping the planes enables the operator to easily turn corners and preserve the equilibrium of the machine.

ELEVATION PLANES

A pair of elevation planes is fitted in front of the main planes with a half-round vertical plane between as shown at *a*. The elevation planes serve to regulate the height of the machine, and when in flight a slight upward movement of the planes will cause the machine to soar higher, and by depressing them it may be gradually or quickly brought to the ground according to the angle at which the planes meet the air.

The elevation planes are similar in shape to the main planes, but only about one-third the size. A lateral rudder is fitted at the rear of the main planes, and is made of two vertical planes, about 5 ft. 10 in. by 2 ft., and about 18 in. or so apart.

The main planes are attached to two long wooden skates, the elevation planes being fitted to the front upper ends. The machine is driven by two wooden propellers, operating in opposite directions. The propellers have a diameter of 8 ft. or so, and are worked by a 4-cylinder motor.

The next aeroplane to attract attention was the Voisin machine, brought into prominence by Farman. The machine is illustrated at Fig. 2, page 49, and it will be seen that it is really a long box kite, with another small one as a tail. The main planes are about 32 ft. long and 6 ft. 6 in. wide and apart. The uprights are covered in canvas to give stability, making three compartments in all. The single elevation planes, attached to the end of the body, measure about 13 ft. over all and 3 ft. wide, and are regulated by levers attached to the driver's seat. In the middle of the tail planes there is a vertical rudder. This is operated by a steering wheel. There is one propeller fitted behind, driven by a motor, mounted on a framework, known as the fuselage, and covered with rubbered cloth. The propeller is secured directly to the main shaft of the engine, and is about 7 ft. 6 in. in diameter.

The attention of aeroplane makers had been directed to the invention of a monoplane, and Bleriot designed the first practicable machine. A small type of his monoplane was used by him in his memorable flight across the Channel to win the $5,000 prize.

The larger type shown in Fig. 3, page 49, is composed of one main plane, which measures over 40 ft. from tip to tip, and about 6 ft. 6 in. in width. The ends are widely rounded off and both upper and lower surface covered with fine canvas. The curvature of the wings is rather more than that of the Wright Brothers' main planes. The main plane is attached to a girder form of framework, which takes the engine and propeller in front, and at the tail is fitted a fixed tail plane and two elevation planes. A vertical rudder is fitted on top and to give greater lateral stability a jib-shaped fin is placed along the top of framework.

The smaller cross-Channel type has two wings fitted each side of the body, making a total length of 28 ft. or so, and a depth of 6 ft. The total length of the machine is about 26 ft. There is a fixed tail, and at each end of it are fitted elevation planes, which also act independently as ailerons. The vertical

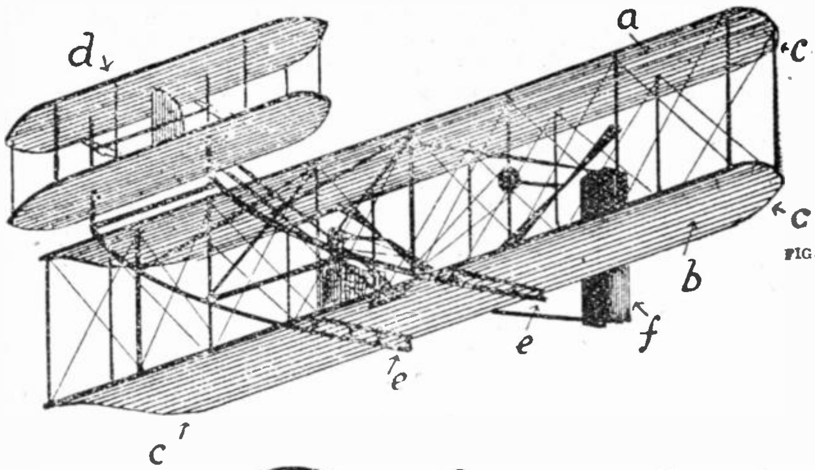


FIG. 1.

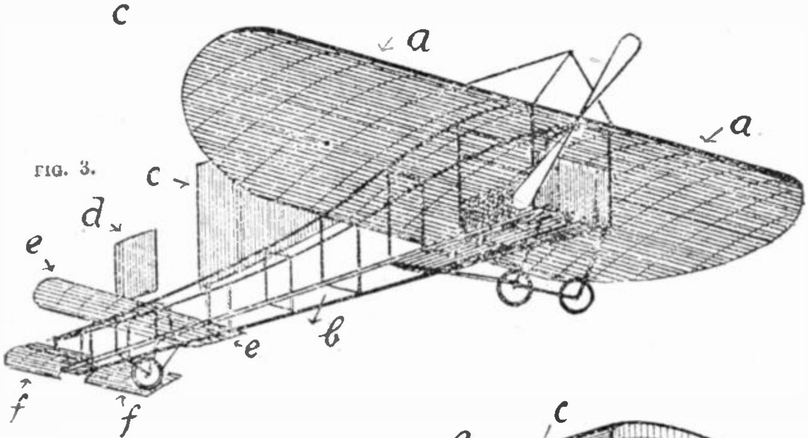


FIG. 3.

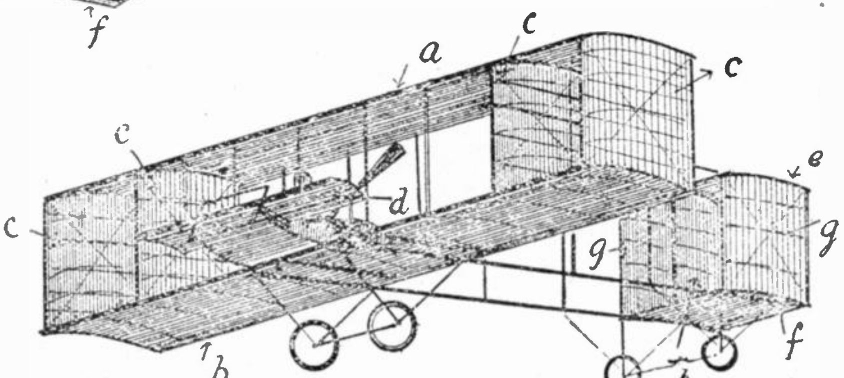


FIG. 2.

rudder is fitted directly on the end of the framework, which is of similar girder form to the first described.

The Cody bi-plane is the largest and heaviest of any of the bi-planes, weighing over one ton. The planes are covered with rubbered canvas and are quite flat, with a length of 52 ft. and width of 6 ft. 9 in. The framework is tubular, and there are six pairs of uprights, securing the upper and lower main planes. There is a large elevation plane in front and a vertical rudder in front, as well as at the rear. At the end of main planes ailerons are fitted which act as stabilisers. The aeroplane is fitted with two propellers.

The Short bi-plane, with which Moore-Brabazon has recently won the $5,000 prize for a circular mile with an all British machine, is a type of Wright bi-plane. It has ailerons at the ends of the main planes, and is shorter and more compact than the Wright machine.

THE OPERATION OF A MODERN POWER HOUSE

H. WINFIELD SECOR

When first looking in the door of a modern power house, the eye rests upon what seems to be an endless array of turbines, dynamos and a multitude of other apparatus which is busy, generating the electric current required for a large industrial plant, or a whole city.

The writer will attempt, below, to give an insight into some of the mysteries which usually surround a power station, in the minds of the lay reader.

A station has been selected which is in actual operation, and has an output of 1,500 h.p. A description will be given of the principal apparatus used in it, and the method of operating same, during a typical day's run.

Fig. I is a floor plan, showing the general arrangement of the plant; (1) is a steam turbine running at 3,600 revolutions per minute direct connected, to a 1,000 k.w. a.c. generator, or "alternator;" (2) forming a "turbo-alternator," unit. This unit supplies a 3-phase a.c. to the panel *A*, of the a.c. switch-board, (10) at a pressure of 220 volts per phase.

Machine No. 5 is a motor-generator set, consisting of a small 3-phase induction, starting motor; a d.c. generator and a 3-phase synchronous a.c. motor, all rigidly connected to the same shaft. The purpose of the starting motor is to bring up the speed of the set to the proper point, as the synchronous motor is incapable of starting itself. This set is sometimes run with the d.c. generator as a motor, and the synchronous a.c. motor as a 3-phase alternator.

At (3) and (4) is placed two small exciting dynamos, which supply d.c. through panel *C*, to excite or charge the field magnets of the large alternating current machines.

One exciter is sufficient for ordinary work, the other machine being a reserve machine. The armatures of these dynamos revolve at 1,500 revolutions per minute, being reduced from the initial turbine spindle speed of 15,000 revolutions per minute by gearing.

Two 8,500 volt series arc-light dynamos are shown in Fig. I, at (6) and (7). These dynamos are direct driven, by d.c. electric motors coupled to them, through insulated couplings. The high voltage arc current is led to the plug switch-board (11), from which it is distributed to the various circuits, by inserting plugs in the proper openings in the board.

A direct connected, engine driven unit is represented by (8), Fig. I; this consists of a regular horizontal steam engine driving a d.c. generator, with a capacity of 300 h.p. This generator supplies d.c. to panel *F* of the d.c. switch-board (9).

The day engineer, arriving in the morning looks over the turbines, dynamos and switch-boards, ascertaining if everything is all right. Total load watt meters, steam pressure and vacuum gauges are read and the readings marked on the daily report sheet. This done, one of the exciters is started up and its voltage adjusted to read 110 by means of its field rheostat on exciter panel *C*.

Now the 1,000 k.w. unit is slowly brought up to speed, which requires about 20 minutes, owing to the abnormal speed at which it runs, 3,600 revolutions per minute, or 60 revolutions per second. When it has reached full speed, its field excitation switch is thrown in, which will cause it to generate current immediately. The voltage of the 3-phase a.c. is regulated by the alternator field regulator on panel *A*, and also by the exciter field regulator in panel *C*.

The motor generator set No. 5 is generally used to furnish d.c. to the d.c. distributing switch-board (9). This necessitates driving the d.c. generator by the synchronous motor. The first operation is to throw in the starting motor switch in bottom of panel *B*. This motor, being simply an induction motor, soon accelerates the speed of the set to the required degree.

The reason the synchronous motor is used to drive the set, is because of its balancing effect on the 3-phase system, and also because of its constant speed.

The synchronous motor has now to be synchronized with the big alternator, which is accomplished as follows: Near the top of panels *A* and *B* are located two lamps, known as synchronizing

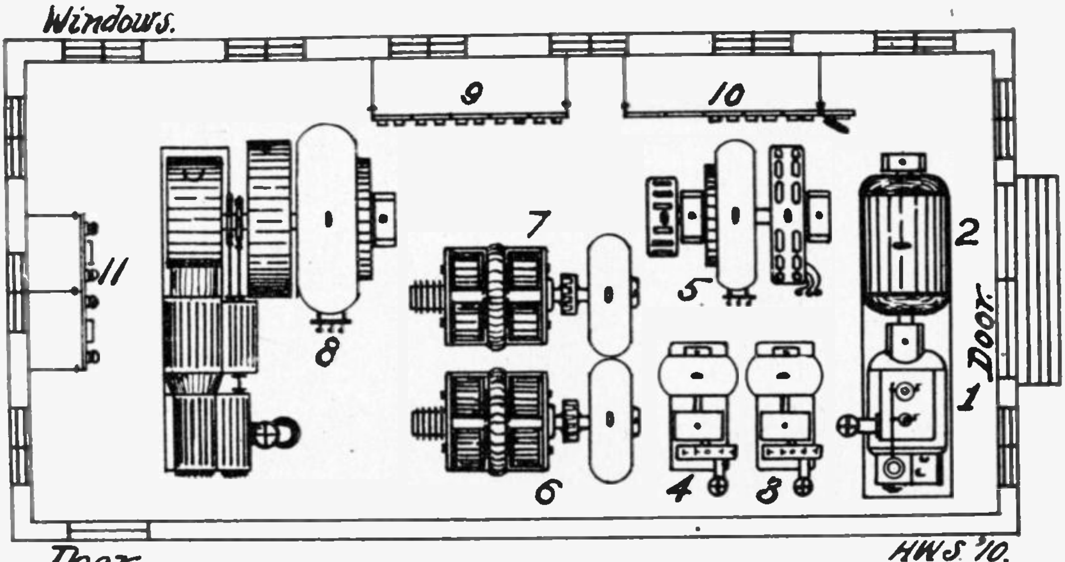


Fig. I

lamps. These lamps are connected to the secondaries of two small transformers, whose primaries are connected to one of the phases of each machine.

The lamps may be arranged to be either dark at synchronism or bright. In this station they are connected so as to be dark at synchronism.

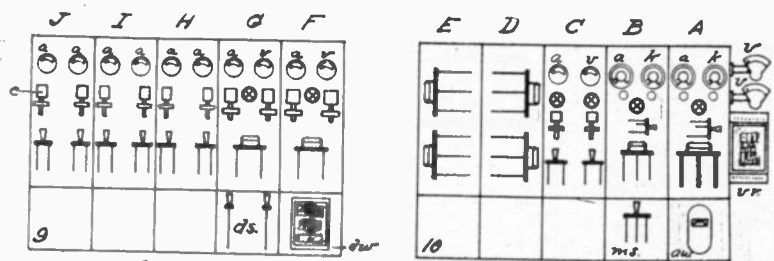
Having brought up the motor generator set to full speed, the synchronous motor field switch on panel *B* is thrown in, which will cause the synchronizing lamps to begin to flicker, the frequency of the flickering dying down as the machines approach synchronism. When the "critical point" is being approached, the lights will be dark about ½ second at each interval. The main switch of the synchronous motor is now put in such a position that it can be quickly thrown in.

Now, with the hands on the switch handle, the lamps are watched closely, and they should be dark about 1 second at each interval by this time. When they stay dark about 3 to 4 seconds the switch is thrown in quickly, and as near the centre of one of these dark intervals as possible. There is a slight rumbling, a squeal or two, and the motor and alternator have been synchronized, one of the most difficult tasks that power-house men have to perform. If the switch is not thrown in at just the proper instant, untold damage may result.

The d.c. generator of the set is now supplying d.c. to the panel *G*, of the d.c. switch-board (9). The switches on panels *H*, *I* and *J* are now thrown in, which connects the distributing feeders to the d.c. supply. The switches on panels *D* and *E* are also put in which livens up the a.c. power feeders,—with 3-phase a.c. at 220 volts pressure per phase, at 60 cycles.

As the load has been gradually rising on the turbo-alternator unit, the corresponding voltage drops, having been rectified by manually operating the field regulators above referred to. After the load has been put on, the "automatic voltage regulator," on auxiliary panel *K*, is switched into circuit, which automatically regulates the voltage and keeps it constant for all variations of load, thereafter. It is disconnected before removing the load.

As night approaches the arc-light dynamos (6) and (7) have to be started up to supply the arc-light current. The d.c. motors driving them are supplied with power from the d.c. dynamo of the motor generator set No. 5. The starting switches for these motors on the bottom of the arc switch-board (11)



a = ammeters. dw = D.C. wattmeter. k = kilowattmeters. aw = A.C. wattmeter.
v = voltmeters. ds = #5 dynamo Sw. ms = 3 Ph. motor Sw. vr = voltage regulator.
c = circuit-breakers

Fig. II. H.W.S. '10.

are thrown in, and the motors allowed to reach full speed, before putting any load upon the dynamos.

These dynamos, as stated before, deliver a constant current of 6.6 amperes at a pressure of 8,500 volts. Before attempting to manipulate the switches carrying this current, heavy rubber gloves are donned. Then standing on a rubber mat 1 in. thick, the arc-dynamo switches, four on each machine, are opened to connect the arc lights into circuit.

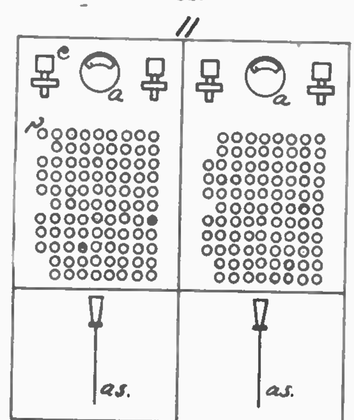
The greatest care is necessary while these machines are operating, as instant death awaits any one who may accidentally touch live parts of the machine with bare hands. Most all the deaths from high voltages have been due to carelessness, and it is generally experienced men who are the victims. One reason for this seems to be due to the truth of the old saying, "Familiarity breeds contempt," which is often exemplified in the electrical profession.

Handling high voltage circuits day after day breeds more and more contempt for them, it seems, until finally a switch is opened or closed without the proper precautions and fatal results follow.

This power house being part of a large industrial plant will not require much power after 6 p.m. in the evening, so the big alternator is to be cut out; this to be done, however, without interfering with the arc-lights. The engine driven set No. 8 is started up and the voltage of the d.c. dynamo adjusted to correspond with that of the d.c. dynamo, No. 5, now running. The equalizer switches on both d.c. machines are next put in. Now cut out the voltage regulator on panel *K*. When the votages of the two machines are both alike, the main switch of dynamo No. 8, on panel *F*, is thrown in. This puts both d.c. machines on parallel, and it is possible to disconnect the dynamo No. 5, by pulling out its main switch on panel *G*. The dynamo No. 8 will now carry the arc-light motors and their load.

To cut out the synchronous motor driving set No. 5, its main switch on panel *B* is pulled out and shortly afterward its field switch. The 3-phase a.c. circuit switches on panels *D* and *E* are also pulled out, leaving the big alternator running empty or without load.

Its main switch on panel *A* is now pulled out, then its field switch, and lastly the throttle on the turbine is closed. The machine is now ready for its next day's run. The exciting dynamo which has been running all day is now shut down, and the other one started up. This equalizes the wear on both machines.



p = switch plug holes.
as = arc motor starting switches.

Fig. III. H.W.S. '10.

The plant, as it is now running, is supplying d.c. power only, but a small amount of a.c. power is usually required. To obtain this, the motor generator set No. 5 is run backward, utilizing the 3-phase synchronous motor as a 3-phase a.c. generator now. To do this, the d.c. generator of the set is started up as a d.c. motor, by putting in starting switch on bottom of panel *G*, the d.c. being supplied by the dynamo No. 8.

When the set is up to speed the field switch of the synchronous motor (now an alternator), is put in, energizing the field magnets. When the a.c. registers 220 volts, the main motor switch on panel *B* is thrown in. This livens up the a.c. power panels *D* and *E*, and the a.c. power required is supplied from the proper switches on these two panels. The plant is now ready for the night run. The next morning the same routine is followed, as outlined above, of course, shutting down the arc machines, set No. 5 temporarily, and dynamo No. 8.

The big turbo-alternator is again started up and then the set No. 5, running the synchronous motor as a motor this time, as explained in the beginning of this article. Fig. II shows the front of the a.c. and d.c. switchboard. Fig. III shows the front of the arc switch-board.

GROWTH OF ALUMINUM CASTING

Remarkable Progress in Ten Years Coincident with Expansion of the Automobile Trade

Attention is directed to the rapid growth of the aluminum casting industry by the announcement of the consolidation of six of the largest aluminum foundries in the country, says the *Iron Trade Review*. Less than ten years ago, the casting of this metal was still in an experimental stage, and the knowledge of its behavior in sand molds was an unknown quantity. Having a low melting point and being easily melted in a cast iron pot, if no crucibles were at hand, the production of castings from this metal proved exceedingly attractive to many foundry men. Furthermore, the exceedingly high prices that prevailed, ranging from eighty cents to $1.25 per pound, were the magnets that drew many founders into this line of work. At that time, however, it was not generally known that this metal was easily affected by the oxidizing influences of the melting flame, and the difficulties encountered after losses more or less heavy had been sustained resulted in centralizing this work in a few shops where a specialty was made of this line of work. Today, provided the metal is properly handled, not only in melting but in the molds as well, little trouble is experienced from the difficulties encountered in early practice. Owing to its lightness, this metal has entered largely into automobile construction, and parts not subjected to severe strains are now made from it. Aluminum crank and gear cases of the most intricate design are successfully cast. The high shrinkage is overcome by the judicious use of risers, and many chills are also placed in the molds.

The growth of this industry has been coincident with the expansion of the automobile trade, and it has been asserted that the six plants consolidated will consume approximately 8,000,000 lbs. of aluminum per year. This concern will be by far the largest user of aluminum in the world, although a large outlet for this metal is found in steel works, where it is extensively used.

A test of Thomas A. Edison's storage battery car was recently made at West Orange, N.J. The car is 26 ft. long and weighs 5 tons. It was fitted with two 7½ h.p. motors, and the operating cost is estimated at one cent a mile. During the test the car was operated at a speed of twenty miles per hour. The motors are operated at 110 volts, and it is claimed that a run of 150 miles can be made without recharging the batteries.

A CHEAP NINE-INCH REFLECTING TELESCOPE.—Part IV

Figuring a Parabolic Speculum

M. A. AINSLEY

So much has been written on the subject of figuring a parabolic speculum, and so well has the matter been explained, that it may seem rather a waste of space for me to try and repeat what has been so often said before; but as I said in my first letter, I am writing for beginners, and I will ask the experts to bear with me if I tell them things they already know much better than I do.

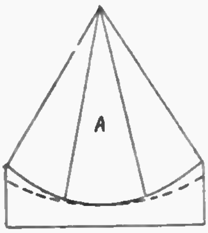


FIG. 1.

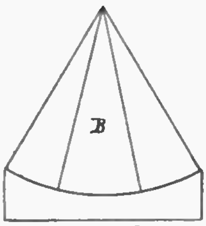


FIG. 2.

Before beginning the practical figuring of a mirror, it is very necessary to have a clear idea of the effect of various curves upon the image formed by the mirror, and a little trouble taken in mastering the theory will render the practice much easier.

Speaking generally, the curve produced by polishing the fine-ground mirror (and I use the word "curve" as practically signifying the same thing as "surface" in this connection) falls into classes, which I shall call *A*, *B* and *C*.

In class *A*, the curvature is greatest at the edge, and decreases regularly to the centre of the mirror, where the curve is flattest. This is known as the "oblate spheroid" (Fig. 1).

Class *B* consists of the sphere, in which, of course the curvature is the same all over (Fig. 2).

Class *C* contains the ellipse, parabola and hyperbola—in all of which the curvature is greatest at the centre and least at the edge. I shall call these C_1, C_2 and C_3 (Fig. 3).

Now let us consider the action of these curves upon a pencil of parallel rays, such as we get from a star.

The effect of classes *A* and *B* is to bring the rays falling upon the outside zone of the mirror to a focus of the central rays. This is also the case, C_1 (Fig. 4). C_2 brings all the rays to the same focal point. This is what we want: (Fig. 5). C_3 brings the outside rays to a focus further from the mirror than that of the inside rays, the effect being the exact opposite of that of *A*, *B* and C_1 (Fig. 6).

Now the only way, practically speaking, of obtaining a pencil of parallel rays is to utilize the rays from a star; and if we were confined to testing the mirror in the telescope on a star, a good deal of time would be lost waiting for a suitable occasion; so it is necessary to find some test which can always be applied. Before passing on, however, it is well to say something as to the appearance of the image of a star, in the telescope, as given by the various classes of surface.

In the case of C_2 (the parabola), if the image is focused as carefully as possible, and the eyepiece is then pushed in or pulled out, the image expands into a circular patch of light which is uniformly bright, and presents the same appearance inside and outside the focus (Fig. 7*a*).

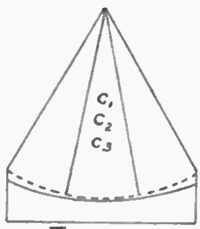


FIG. 3.

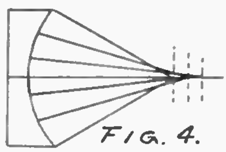


FIG. 4.

In the case of *A*, *B* and *C* the image inside the focus will have a dark centre, while outside the centre will be brighter than the rest of the circle (Fig. 7*b*). C_3, the hyperbola, gives exactly the opposite effect, the patch of light having a bright centre inside the focus, and a dark centre outside (Fig. 7*c*). It will thus be seen that it is possible to judge of the correctness of the curve of a mirror by actual testing a star in a telescope; but, as I said, the speculum worker does not, as a rule, care to wait a fortnight for the chance of getting a view of a star, as is sometimes necessary.

The practical method adopted is to make use of an artificial star, formed by a pinhole in a plate of metal, and placed at the centre of curvature of the mirror. Being at the centre of the curvature, the image of the pinhole will coincide with the pinhole itself; so it is necessary to move the pinhole a little to one side in order to view the image. This does not practically affect the results except with mirrors of abnormally short focal length.

The action of the various classes of curve, however, is somewhat different from the former case, where the star was at an infinite distance, and the incident rays of light consequently parallel. In the present case they are divergent from the centre of curvature, and the

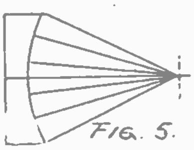


FIG. 5.

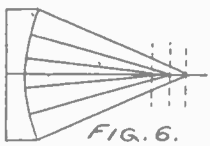


FIG. 6.

difference between the condition of the two cases must be carefully noted.

Upon the new conditions, class A brings the outer rays to a focus nearer to the mirror than the inner (Fig. 4).

Class B brings all the rays to the same focus (Fig. 5).

Classes C_1, C_2, C_3, all bring the outer rays to a focus further from the mirror than the central rays (Fig. 6).

Again, if the image be examined with an eyepiece, as in a telescope, class A gives a bright centre outside and a dark centre inside the focus (Fig. 7*b*).

Class B gives the same appearance inside and outside (Fig. 7*a*).

And class C_1, C_2, C_3 gives a dark centre outside and a bright inside the focus as in Fig. 7*c*.

It will thus be seen that, viewed with the eyepiece, C_1, C_2, C_3 gives the same appearance, differing only in degree, and it thus becomes necessary to have some means of determining with certainty when the parabola C_2 is obtained.

If the eye be brought close up to the image of the pinhole so as to receive the whole pencil of rays reflected by the mirror, the whole mirror will be seen illuminated, and if a screen of metal be brought across the pencil of rays in the neighborhood of the image of the pinhole, it will cut off the light and apparently darken the surface of

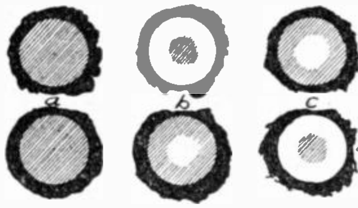


FIG. 7.

the mirrors seen by the eye. Its action, however, will be different, according as it is between the mirror and the image or beyond it.

Suppose the screen is always moved across from right to left; then if it is within the focus, *i.e.*, nearer to the mirror than the image of the pinhole, it will be seen from Fig. 8 that it will darken the right-hand side of the mirror first; if it is exactly at the focus, the mirror being supposed spherical, the mirror will darken evenly all over, while if outside the focus, the shadow will appear to move from left to right, or in a direction opposite to the motion of the screen (Fig. 9). Thus, if the shadow moves the same way as the screen, the screen is known to be inside the focus; if the opposite way, the screen is outside the focus; while, if the screen

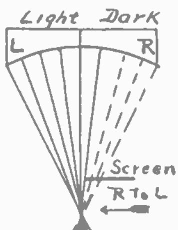


FIG. 8.

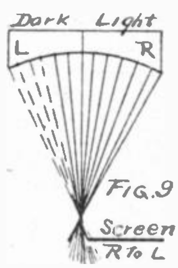


FIG. 9

is exactly at the focus, the mirror will darken uniformly and with very great rapidity as the screen is moved across.

This gives us a very accurate means of placing the screen exactly at the focus of the mirror for rays diverging from the centre of curvature; and what is true of the whole mirror is, of course, true of any part of it; so that, if the

FIG. 10.

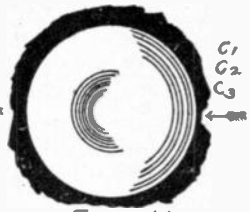


FIG. 11.

mirror is divided up into zones, and if all the mirror except the zone under examination is stopped out by means of a screen placed over the mirror, it is possible, by observing the point at which the zone darkens uniformly, to place the screen with very great accuracy at the focal point, for divergent rays, of any given zone. Thus the divergence in focus for different zones can be easily measured.

Before proceeding, however, to the actual measurement of the focal point for the different zones, it is as well to make an examination of the three classes, *A*, *B* or *C*, it belongs to. As before said, in the case of class *A*, the outside rays will come to a focus nearer to the mirror than the inside rays; consequently, if the screen is placed as near as possible to the image of the pinhole, so that the mirror darkens as uniformly as possible as the screen is brought across, the screen will be inside the focus for the central rays, and outside the focus for the marginal rays. Thus the shadow will advance across the mirror from left to right for the centre, and from left to right for the margin, the screen being always carried across from right to left. The appearance of the mirror is shown in Fig. 10. In the case of the sphere class *B*, the darkening is uniform all over: while with class *C*, since the screen is now inside the focus for marginal rays and outside for central rays, the shadow will advance from left to right for the centre, and from right to left for the outside, the appearance being exactly the opposite to that for class *A* (Fig. 11). C_1, C_2 and C_3 all give the same appearance as regards this test, and it is absolutely necessary to submit the matter to exact measurement, as there is no other reliable way of deciding when C_2, the parabola, is exactly attained.

The method, then, is to divide the surface of the mirror into zones by means of card screens placed against it, and to determine, by means of a screen brought across the image of a pinhole, what the exact position of the focus of any zone is.

In practice it is only necessary to measure the position of the screen for the central 2 in., and for the outside inch or so. An examination of the mirror as a whole will show whether the curve is regular, or whether there are any rings; though if the polisher is carefully made, as before explained, rings ought not to appear.

In my next chapter I hope to give the formula for determining when the parabola is attained and the practical details of the testing.

Locating Grounds in Buildings

A handy device for locating the points where wires are grounded can be made by taking a U-shaped yoke of iron and winding on it a coil of very fine wire and connecting the ends of this wire to a telephone receiver. When the yoke is brought near to a wire carrying a current a buzzing will be heard in the telephone receiver, and grounds within the walls of a building can be located when carrying a current by moving the yoke along the wall. The method of locating a ground is as follows:

All the lights are turned off and the main feed tested; if there is a meter, care must be taken to get beyond it, as the current taken by the constant potential coil is sufficient to make the receiver buzz. If a buzzing is heard it can be traced to one of the branches, and this can be followed along the walls until a point is reached where the buzzing ceases, or is very much diminished. This is the point where the current is leaving the conductor, *i.e.*, the grounded point. This apparatus works on both alternating and direct current, but is very much more delicate on the former.

ROBT. E. BRADLEY.

The man who is always putting his foot down is pretty sure, in time, to encounter a tack.

CAST IRON BRAZING AND AUTOGENOUS WELDING.—Part II

Autogenous Welding

F. A. SAYLOR

Autogenous welding is the uniting of metals by heat without the use of flux or compression or additional metal. It is, in fact, a self-produced union and the term as used is a misnomer. What is known as autogenous welding should properly be called fusion welding. The use of the word welding is not altogether correct either, as that commonly implies the use of force, as hammering or compression, whereas it is more on the order of casting as the metal is united by flowing together as in a mold.

Autogenous welding, to give it the name commonly applied, has been in use for a long time by means of oxy-gas and oxy-hydrogen, but has been limited in application until the development of the oxy-acetylene process placed it on a commercial basis and caused a rapid improvement in methods and extended the range of work.

This is a day of rapid change and what is accepted as new today is superseded tomorrow by something superior, and the old tool or method is consigned to history: so, as the oxy-gas and oxy-hydrogen processes have been superseded by the oxy-acetylene, we will discard them and consider only the latter.

Apparatus.—The apparatus consists of three parts: a torch, a tank containing oxygen and a tank containing acetylene, or an acetylene generator. The torch is the most important and vital portion, as it is the thing of all others upon which success finally depends. Three kinds of torches are in use, known as the high pressure, medium pressure and low pressure, according to the condition under which the acetylene is supplied.

The high pressure torch is not used in the United States and the medium pressure torch is commonly known in this country as the high pressure because one of still higher pressure was never introduced.

The low pressure torch uses acetylene at practically no pressure depending on the injector action of a jet of oxygen to draw in the acetylene.

The medium pressure torch mixes the gases under pressure, and it is claimed that a more regular and homogeneous mixture is attained with less danger of change and of flash-back.

The oxygen is generated by any one of the numerous commercial methods, such as the potassium chlorate and manganese dioxide, bleach powder, liquid air, barium oxide and many others, and is compressed in tanks by means of a compressor, or by force of generation. These tanks are made to hold, as a rule, 100 ft. of gas ranging in pressure from 250 to 1,800 lbs., according to size.

The acetylene is supplied compressed in tanks or from a generator.

This gas cannot be safely compressed above 30 lbs. pressure, consequently it was necessary to find some medium whereby it could be safely handled. After considerable experiment it was found that acetone, a wood tar distillate, had the property of absorbing 25 volumes of acetylene for every atmosphere of pressure and it is possible to dissolve 125 ft. of gas and place it in a receptacle 10 in. in diameter and 30 in. long. The dissolved acetylene tanks are filled with disks of asbestos, or other absorbent material saturated with acetone and the gas is pumped in till the pressure gauge shows that the required amount has been reached. These tanks can then be safely handled and form a convenient method of supplying the gas in places where a generator is not required or impossible to use.

The torches use the gases at varying pressures depending upon the size of the work to be done, and, as the tanks are compressed to a very much higher pressure than is used at the torch, reducing valves are attached to cut the tank pressure down to that needed by the torch. As this pressure varies, the reducing valves are designed so that the pressure of the gas delivered at the torch can be increased from zero to the highest amount necessary.

Method of Use.—The torch in its simplest form consists of two pipes, joined at their extremities into a chamber where the gas is mixed and from which it flows as a mixture to be ignited. The tube containing the acetylene is provided with screens or a packing of some porous material to prevent flash-back, but the oxygen tube is unobstructed in any way. In operating the torch the oxygen tube is connected with the tank through the reducing valve and the acetylene tube with the generator or dissolved acetylene tank in the same way. The acetylene is then turned on and lighted at the nozzle of the torch. Pressure is adjusted until little or no smoke appears and then the oxygen is admitted. As soon as the oxygen reaches the nozzle a change takes place in the appearance of the flame; from a yellow it turns to a blindingly bright white. As the pressure increases the flame divides, showing a ragged core of white and an outside envelope of yellow. Increase the pressure further and gradually the inside cone takes a sharply defined outline, oval in shape and of very small length and diameter. Surrounding it is a large cone of a more yellowish hue but which is clearly separated from the inner flame. The inside flame is the working portion and the outside envelope, while it is of importance inasmuch as it protects the weld against oxidation, is not of great value. The heat derived from this flame is about 6,300°, which is 2,000 higher than that attained by the oxy-hydrogen torch and slightly less than that of the electric arc.

Practical Uses.—The process has been used extensively by pipe manufacturers in making up manifolds, headers, etc., and in repairing split and broken pipe; also for making up long sections without screw or flanged joints. Boiler manufacturers are using it extensively in making up range boilers and in repairing work, and sheet metal workers are changing the design of a great deal of their work to allow of its use. Many plants are putting it into use as a repair tool in reclaiming broken and damaged castings, while steel casting foundries are finding it invaluable in reclaiming defective work.

Cost of Operation.—The cost of operation varies as the size of the torch or tip increases. More gas is used with the large sizes than with the small and labor being a fixed charge the cost of operation depends upon the consumption of the gases. On an average the cost of operation would be from 1 cent a ft. for 1/32 in. sheet iron upward to 40 cents per ft. for ½ in. steel, taking labor at 30 cents per hour. For cast iron these figures would have to be reduced and increased for copper.

Cost of Apparatus.—The apparatus ranges in cost from $300 to $2,000 according to the type and size and dependent upon the installation of an oxygen generating plant; but the average price for a unit plant, consisting of acetylene generator, two oxygen tanks, torch, hose, valves, gauges, etc., would be about $500.

Operators.—To successfully operate a plant requires some knowledge and skill which are attained only by experience. An operator requires a steady hand and wide knowledge of the effect of contraction and expansion, if he intends to go into the general repair business; but where the work is confined to restricted lines, such as sheet steel or pipe work less knowledge is necessary, but like everything else experience must be had before success is attained.

Accidents.—Comparatively few accidents have occurred since the apparatus has been introduced into this country, and without exception they have been caused by carelessness or ignorance and have usually resulted in bringing fire too close to the acetylene generator. Now acetylene forms an explosive mixture with oxygen and the range is very great, from about 3% to 38%, so great care should be exercised in handling it. However, everything being taken into consideration there is no doubt but that the autogenous welding process has come to stay and is a very valuable addition to the tools we have at our command.

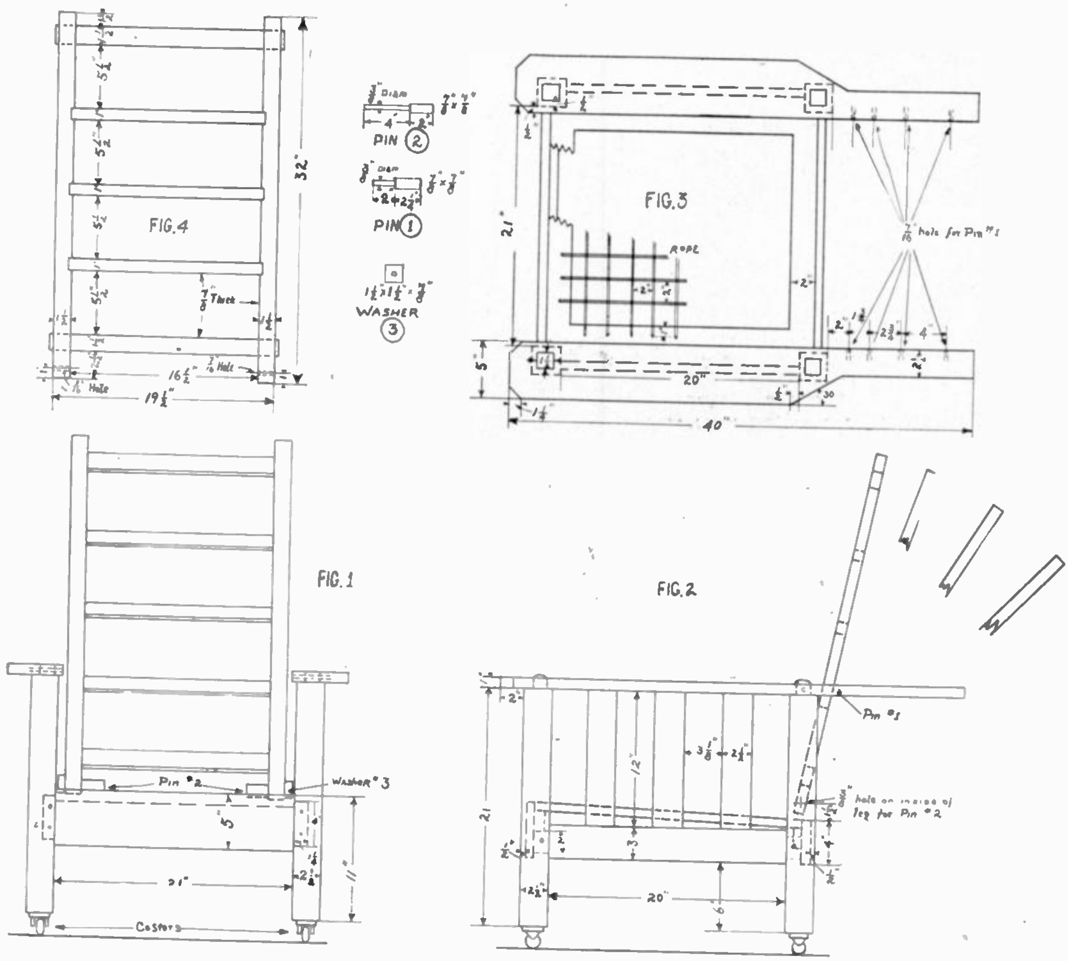
According to a consular report, Sir Oliver Lodge has recently demonstrated the efficiency of his fog-clearing apparatus in Liverpool. He succeeded in clearing a thick fog over a radius of 60 feet. The Lodge system consists in discharging electricity at high voltage from a series of disks, with the result that the fog is condensed and falls to the ground. The apparatus will soon be tested in London.

HOW TO MAKE A MORRIS CHAIR—MISSION STYLE

IRA M. CUSHING

The Morris chair described here can be easily built by any one who can saw straight and use a chisel without splitting off the corners. It will be found a great addition to the den or living room, and its style, which is mission, will go well with any other mission furniture. The cost is small in comparison with the usefulness and comfort of the chair. The wood, if it is oak, will not cost over $5.00 if the builder lives near a city or town or a planing mill. It should be purchased planed to the final finish, as this adds but very little to the cost and not only saves much hard work but also gives a uniform finish to the chair. It does not seem hardly necessary to caution the builder to make all saw cuts very carefully using, if possible, a fine toothed saw, and to make all cuts as near right angle as possible. Preserve, if you can, all the sharp corners, as this is one of the chief characteristics of mission furniture.

The legs should be got out first. These are 2½ in. square and 22¼ in. long with the top reduced to 1½ in. square for about 1⅛ in. to 1¼ in. where they pass through the arm pieces. The side and end pieces are inserted into the legs 1¼ in. These pieces should have a shoulder to rest against the legs. The cut for the sides should therefore be 2 in. long, for the back 3 in. long, and for the front 4 in. long. The drawings show the locations of these cuts. On the inside of the hind legs a ⅜ in. hole should be made for the pin of the back. These holes should be 11½ in. from the bottom and 1¼ in. from the front or back. The horizontal side pieces are of ⅞ in. stock and 3 in. wide except a distance of 1¼ in. which is 2 in. wide, the cut being made ½ in. from each side. For the vertical slats cut slots ¼ in. wide, ¼ in. deep and 2½ in. long spaced 3⅛ in. apart as shown and equal distance from each side. For the slats get out pieces 2½ in. wide, ¼ in. thick and 12½ in. long. These should be inserted into the under side of the arms ¼ in., same as in the lower piece. For the arms, get out two pieces 40 in. long, 5 in. wide and 1 in. thick. Cut as shown in drawing, and bore four



MORRIS CHAIR

L. M. CUSHING FEB. 1909.

3/8 in. holes on the inside at the back end, centered and spaced as shown and about 2 1/4 in. deep.

The sides can now be assembled. Insert the horizontal piece, using glue. Put the vertical pieces in place in the horizontal piece with glue and then put the arm in place putting glue on the ends of the slats and around the tops of the legs where they touch the arms. With a furniture clamp or similar device, hold the sides firmly from front to back and bore 3/8 in. holes through the legs from the outside for pins to hold the horizontal pieces to the legs. These should be located 3/4 in. from the edge and on the centre line of the sides. They need not be bored way through, but only about 2 in. deep. Now turn the side around and hold the arm rest firmly on the legs and bore for pins through the arm from the inside and into the top of the legs. The front piece, 5 in. wide, and the back piece, 4 in. wide, should be got out and put in place in the same manner as the side pieces, fastening them in place with dowell pins and glue.

A frame should next be made to fit inside the chair to hold the cushions. This is constructed of 2 x 7/8 in. stock laid flat, fitting snugly inside the front and back pieces and at the sides fitting inside the legs. A rope support for the seat should be made by interlacing rope, ¼ in. in diameter, front to back and from side to side through holes in the frame. To support this frame a piece of 2 x ⅞ in. stock about 1 ft. long should be fastened on the inside of the front and back pieces. Screws and glue should be used and the pieces located so that the top of the frame will be flush with the top of the front and back pieces. At the sides this frame should be supported by pieces of 2 x ⅞ in. stock securely fastened to the legs.

The back is made of ⅞ in. stock. The sides and end pieces are 1½ in. wide and the inside cross pieces 1 in. wide. The end pieces are dovetailed into the side pieces with a ¼ in. tongue centrally located and held by dowell pins and glue. The inside cross pieces are inserted ¼ in. into the side pieces to prevent turning. Glue should be used when putting them in and a finish wire nail driven in from the outside. A 7-16 in. hole should be bored in the bottom of the sides.

Two each of pins No. 1 and No. 2 and washer No. 3 should be made. Pin No. 1 is used to hold the back rest at the desired angle by placing in the holes at the back of the arm rests. Pin No. 2 with washer No. 3 form the hinge for the back.

Any paint or finish may be used to suit the taste of the builder. The writer recommends the mission finishes made by the Adams and Elting Co., Chicago, Ill., and called the "Ad-el-ite," one coat dull finish. This finish is easily applied and durable.

Casters should be put on the legs to make it easy to move the chair. For use on hard floors a wheel having a soft rubber tire should be used; for carpets a hard rubber wheel.

The chair is made to take the standard Morris Chair Cushions. The best color to use is red or green, but any other color which would harmonize with the chair and surroundings is suitable.

The best material to use is quartered oak, which gives a beautiful finish with the "Ad-el-ite" finishes. Any hard wood is suitable, however, as well as any finish.

The author would suggest that the best make of cushions be purchased as will fit the builder's pocketbook, as the best is none too good as regards wearing qualities. The chair will undoubtedly outwear two or three sets.

FORGING FOR AMATEURS.—Part XXI

F. W. PUTNAM, B.S.

I have heard machinists frequently ask the question: "What is the reason that I cannot braze cast iron? Practically every time I try I fail. Sometimes the cast iron burns away and at other times the brass will fail to stick."

As a matter of fact, cast iron may be quite readily brazed, after it has been thoroughly cleaned. Yellow brass, which is used in brazing copper, is an excellent spelter for this purpose, but it must contain a very large percentage of zinc so that its melting point will be much lower than that of the cast iron itself. The borax should be put on before heating the iron, dissolving it and applying the solution freely to the parts to be brazed. The water will hold the borax until it calcines or slakes. By doing this before heating the oxide is prevented from forming upon the iron. Heat the work, gradually applying the heat to the largest piece and keeping that piece the hottest. Use plenty of borax and watch carefully, so as to get the iron up to a red heat before any of the brass melts. When the brass is thoroughly melted, it will run, after which the parts must be removed from the fire immediately and cooled off slowly. In place of the regular spelter brass wire, filings, or even small strips of rolled brass are sometimes used.

The brass wire is especially satisfactory for use in some places, because it can be bent into shape and held in place easily. I give on the following pages several simple examples of brazing, which should be sufficient to acquaint the amateur with the ordinary braze joints with which he might sometimes have to do.

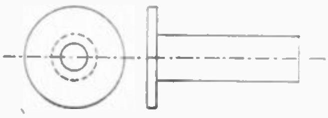


Fig.225

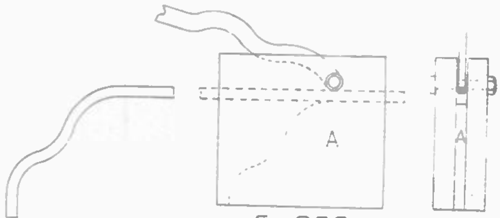


Fig.229

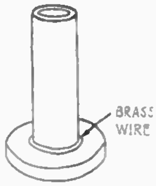


Fig.226

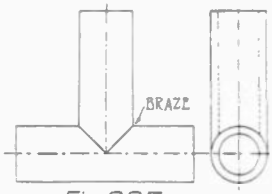


Fig.227

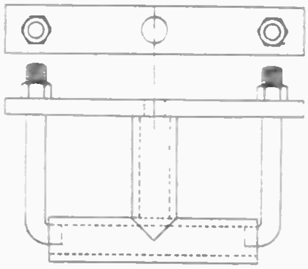


Fig.228

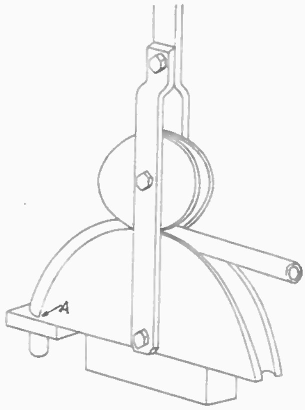


Fig.230

One of the simplest brazing jobs is that of joining ferrules together. The ends of the piece to be brazed are first chauferred on opposite sides and filed, so that the iron will be bright and clean. Then bend so that the ends will lap about ⅛ in. Then lay on a piece of brass, such as an old lamp top or burner, sprinkle on a little powdered borax, throw on a few drops of water and it is ready for the fire.

To braze an iron tube, make two small holes in the tube and two small holes in a piece of iron and pin them together, wrapping binding iron around them. Next take a piece of iron about 1¼ in. thick and 2 in. wide and cut in it a slot, a little longer than the piece of iron to be brazed. Place the tube on the iron sideways, so that you may see what packing you need under the iron that is to be brazed on to the tube. The larger the tube, of course, the thicker the packing must be in order to get it on perfectly straight.

Fig. 225 shows a simple brazed joint, where a large washer would be used if a flange is brazed around the end of a pipe. Here it is not necessary to use any clamps or wires to hold the work together, since the joint may be made tight enough to hold the pieces in place. By this I mean that the joint should be tight enough in spots so as to hold the pieces together, yet open enough so as to allow the melted brass to run between the two pieces. Wherever the pipe comes in contact with the flange, the outside must be free from scale and filed bright and the inside of the flange also should be treated in this way.

After the pieces have been properly cleaned and forced together, a piece of brass wire is bent around the pipe at the bend, as shown in Fig. 226, after which the work is laid on the fire with the flange down. The fire must be a clean, bright bed of coals.

As soon as the work has been placed on the fire, the joint is sprinkled with the flux. Indeed, it is a pretty good plan to put on some of the flux before the work is placed on the fire, where ordinary borax is used as a flux. I find that one part of sal-ammoniac to three parts of borax seems to give rather better results.

The work is to be gradually raised in temperature until the melting point of the brass is reached, which will then run all around and into the joint, after which the piece is taken from the fire. It would be possible to use spelter in place of the brass wire. If the spelter were used, the piece would be placed on the fire and the joint covered with flux as before. As soon as the flux starts to melt, the spelter, which has been mixed with a large amount of flux, is spread on the joint and melted down as usual. The spelter can most conveniently be rounded with the aid of a long-handled spoon, which is very easily made by taking a strip of iron about 1/4 x 1/8 in. and about 4 ft. long and hollowing one end slightly with the pean end of the hammer. I have given elsewhere in this article, the composition of different kinds, in which is included hard and soft spelter. While the soft spelter melts at a lower heat than the hard spelter, it does not make nearly as strong a joint. It is really nothing but brass prepared for brazing in small flakes and can be bought ready for use. To make it, I would recommend the following method: Melt soft brass in a ladle and pour it into a barrel filled with water, the water being given a swelling motion, as with a propeller, before pouring in the brass. The brass will settle to the bottom in small particles. In order not to burn out the zinc when melting the brass, cover the metal in the ladle with coal or powdered charcoal. After the zinc begins to burn, it will give a brilliant flame, and a dense white smoke, leaving a deposit of white oxide of zinc.

Fig. 227 gives another common example of brazing, known as the T-joint, where two pipes are brazed to each other in the form of an inverted T. To hold the pieces in proper position while brazing, a clamp, such as is shown in Fig. 228, is necessary, because one pipe is simply stood on the outside of the other. The clamp shown consists of a piece of flat iron which has one hole near each end to receive two small bolts

This strip lies across the end of the pipe which forms the short stem of the T, and the bent ends of the bolts work into the ends of the bottom pipe, the whole being held together by tightening down on the nuts.

The use of this clamp is very well shown in the figure and needs no further description. As for the operations gone through with in brazing the joint, nothing further need be said, after the spelter or wire is laid on the joint and nailed into place as before.

It is surprising to see how strong a brazed joint is. After a joint of this kind has been well made, and is hammered apart, usually the short pipe will tear out or even pull off a section of the longer pipe, showing the braze to be very nearly as strong as the pipe itself.

If borax is used as a flux, the melted scale should be scraped or cleaned from the work while it is still red hot, since the borax on cooling makes a hard, glossy scale which can hardly be touched with a file. This cleaning is perhaps best done by plunging brazed while still red hot into the water. On small work, it can be well done by plunging the piece while still red hot into melted cyanide of potassium, after which it is instantly plunged into cold water, the idea being that the cyanide will eat off the borax. The danger is that the brass may be allowed to remain in the cyanide too long, in which case the brass will be eaten off, and the braze destroyed.

Fig. 229 shows a method of bending pipe. Figs. 177 and 178, in one of the previous articles, illustrate several methods of bending pipe; but the apparatus shown in Fig. 229 is much more valuable because it may be used for bending several pieces of pipe just alike. It is really a jig, and consists of two wide parts to prevent the sides of the pipe from bulging, and a block which is placed between these parts in order to give the proper shape to the curve.

Fig. 230 shows a piece of pipe which has been bent in such a jig. It was a piece of 1/4 in. gas pipe. To make the jig, use two pieces of oak plank, 1 1/2 in. thick. Place between these sides a board *A*, sawed to the shape of the inside curve of the bent pipe. This piece should be slightly thicker than the outside diameter of the pipe, so as to allow for a little clearance.

The inside ace of the sides and also an edge of the block *A* are protected from the red-hot pipe by a piece of iron nailed to them.

The bending level may be made by bending a piece of 1/2 in. x 1 in. stock into the shape of the outside of the pipe, and is held in place by a ½ in. bolt, which passes through the sides of the jig, as indicated in the figure.

To bend the pipe it was heated to a yellow heat and put in the jig as indicated by the dotted lines, after which the lever was pulled over, thus forcing the hot pipe to take the form of the block. A jig of this kind can be very easily and cheaply made.

Still another common way of bending is to fill the pipe with sand, one end of the pipe to be bended by a clugger, either with a cap or a wooden block driven in tightly. The pipe is filled full of sand and the other end closed up tightly, after which the pipe is heated and bent into shape. It is absolutely necessary to have the pipe full of sand in order to get good results and for very thin pipes melted rosin is generally used, but this, of course, can only be used when the tube or pipe is very thin. It is bent cold, since heating the pipe would cause the rosin to run out. Thin copper tubing is usually bent in this way. Fig. 230 shows another form of the pipe bending jig, where the outside edge of the semicircular casting has a groove in it, that just fits half way round the pipe.

The small wheel which is attached to the lever has a corresponding groove on its edge. When the two are in the position shown in the circle, the hole left between them will be, of course, exactly the same shape and size as the cross section of the pipe.

In bending the pipe, the lever is swung to the extreme left and the end of the heated pipe is inserted in the pocket at A, which has a hole in it the same size as the pipe, after which the lever is pulled strongly back to the right, bending the pipe as it goes. The jig is usually made with a stem to fit in a vise.

BRAZING WITH BRASS OR COPPER

To braze brass or copper, the parts should be filed clean and wired in place or riveted. A few lumps of borax are burned on a piece of set iron and then pulverized, dissolved and dipped on the article to be brazed in it, after which the piece of brass or copper is first sprinkled with borax and put in a clear, blowing very slowly with the bellows until the iron on which the brass has been placed gets red. Then a blue flame, which is the melting point of brass and copper, will be seen. Allow it to lie in the fire a minute with the blast on, then take it out and lay it down gently to cool. Very delicate articles must be dipped in a batter of clay to keep them from burning. When the clay begins to crease, it is then time to take them out of the fire. Brass or copper should be preferably brazed with silver. Copper can be brazed with brass, but the melting point of brass and copper are only a few degrees apart, and so such work is not safe unless you have to deal with a large piece of copper. Brass and copper for brazing perferably should be milled. When silver is used, if possible, use old coin or Mexican coin, the silver being purer.

ANNEALING COPPER AND BRASS

To anneal brass or copper, heat it to a red heat and cool it suddenly in cold water, copper being annealed in the same way that steel is hardened. Copper which has been annealed in this way will be very soft, much like lead. After brass or copper are hammered, they will harden and become springy, so we find when working brass or copper, where much bending or hammering is done, that the metal requires annealing frequently.

BENDING CAST IRON

It is sometimes necessary to straighten castings which have become warped and twisted. This can be done to some extent by heating the iron and bending it into the desired shape. The part to be bent should be heated to what is best described perhaps as a dull yellow heat. The bending is done, but very gradually, applying pressure using two bars or tongs, which should give about the right amount of leverage for twisting and bending. Thin castings, if properly handled, may be bent to a considerable extent, but before attempting any special work, some experimenting had better be done on a piece of scrap iron in order to determine at just what heat the iron will work to the best advantage.

It is odd, isn't it, that in a world full of lost buttons one never by any chance comes upon a lost buttonhole?

ADJUSTMENT OF WATCHES TO TEMPERATURE

S. A. WEAVER

There is probably no part of watch repairing as badly abused or neglected in proportion to its importance as the one to be discussed in this brief article. My experience in repairing watches has been quite varied, having worked in the capacity of watchmaker all the way from some of the finest stores in the large cities down to the less elaborate ones in small country towns, and everywhere alike I have found watches in great numbers crying aloud for adjustment to temperature. These watches must have been disabled by either incompetent or careless workmen, and it is my opinion that it was more from a lack of knowledge of adjustments of this nature than from carelessness on the part of the workmen who repaired them; therefore, in the following article I will try to illustrate and explain this matter in such a simple manner that any one, even though not at all familiar with the mechanism of a watch, will be able to understand, avoiding, as far as possible, the use of technical terms or the discussion of small theories that would tend to bewilder the mind of those who but vaguely understand the principles of adjustment to temperature.

The structure of the watch hairspring, presenting so much surface in proportion to its total mass, is such as to render it peculiarly sensitive to thermic influences. It is a well-known law of nature that all metals expand under the influence of heat; it will be understood, then, that the hairspring, which is so extremely slender, will be very sensibly affected, its length increasing as its temperature rises; and as the spring lengthens, its power, of course, grows weaker, not alone in the mere fact of its expansion in length, but that heat is a devitalizing factor on the elastic force of the spring.

These combined imperfections, or elements of weakness inherent in the spring, were very ingeniously surmounted some years ago by the invention of what is called the compensating balance, which is so constructed that the same heat which weakens the elastic force of the hairspring serves at the same time to reduce the diameter of the balance, so as to exactly adapt it to the force which the weakened spring is capable of exerting. This automatic compensation is obtained by constructing the balance rim of two metals having widely different ratios of expansion. In the ordinary watch, the two metals employed are steel and brass, the arms and inner portion of the rim being of steel, with an encircling band of brass, the two metals being firmly united by fusion. The action of the balance under the influence of heat will be easily understood by a few words of explanation in connection with the following cuts:

Fig. 1 represents a strip of brass and one of steel of equal lengths when at a normal temperature. When heat is applied, the two metals will expand in about the ratio indicated by the dotted lines.

Now if these two strips of metal be firmly united by fusion, as shown in Fig. 2, it is evident that the brass portion of the strip would not be free to expand, being held by its union to the less expansive steel; therefore, the compound strip is forced to assume a curved form, as shown in Fig. 3.

Of course, if the bar had been subjected to a like reduction in temperature, the result would have been that the bar would have been curved in the opposite direction.

The differential expansion of metals, then, is the basis on which the compensating balance is constructed.

The next cut shows a complete balance as used in ordinary watches.

It will be observed that the rim of the balance has been severed at two opposite points, near the arms, so that the rim is practically the same thing as shown in Fig. 2, the difference being that the two compound strips which form the balance rim are curved, instead of straight, the effect of heat on the balance being shown in Fig. 5.

We now come to the little screws on the rim of the balance, which have a double use; first, to enable the balance to possess the exact weight desired, so

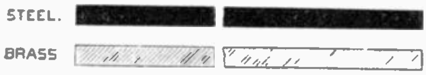


FIG. 1.

FIG. 2

FIG. 3

that, when in connection with the proper hairspring, it shall make the exact number of vibrations per hour required, which in most modern watches is 18,000 per hour. But it makes quite a marked difference in the result obtained where these screws are located, because the matter of temperature is a factor always to be considered. A little consideration of this fact will make clear to you the second use of these little screws, bearing in mind that the object to be attained by the use of this form of balance is to utilize the changing temperature, which modifies the effective power of the hairspring, as to render the balance self-adapting to the various conditions. This is attained by changing the effective diameter of the balance, so that if the heat weakens the spring, it at the same time reduces the diameter of the balance to exactly correspond.

In the next cut we have the screws numbered, and you will observe that between the screws are holes which are adapted to receive screws, and these holes are also numbered.

A careful and accurate trial might show that at a normal temperature (about 70° F.) this balance would have the exact weight to allow the required rapidity of vibration (18,000 per hour). Now subject this watch to an increase of, say, 25° in temperature, and it will very likely be found to lose as much as 7 seconds per hour, or 35 beats or vibrations, which fact will indicate that when in the heat the balance is too large, or, more properly stated, the effective weight is not properly located, being too far from the axis. A careful examination will make it plain that the *effective* weight of a balance can be readily changed without a particle of change in the *actual* weight. In this case it might be simply needful to remove, say, screw No. 4 to position marked No. 11, so giving an added weight at that part of the rim where the effect of the heat would cause it to curl in farthest toward the axis, thereby more rapidly reducing the effective diameter of the balance, and so allow more rapid vibrations. If, on the other hand, the watch had been found to gain when heated, the screws must have been moved in the opposite direction. Manipulations of this sort are always required in adjusting watches to temperature.

There is hardly a day but that fine watches come to my notice in which these screws have been changed about, or exchanged for heavier or lighter ones, extra screws added or some of the original ones taken out by some careless or incompetent workman, without any thought whatever in regard to the effect produced by the change, and, as previously stated, I have found this condition alike in city and country towns.

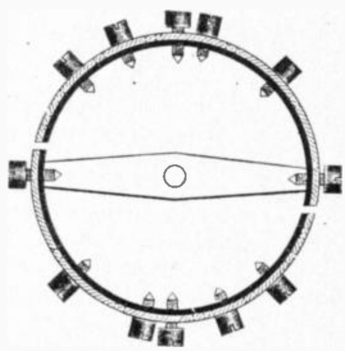


FIG. 4

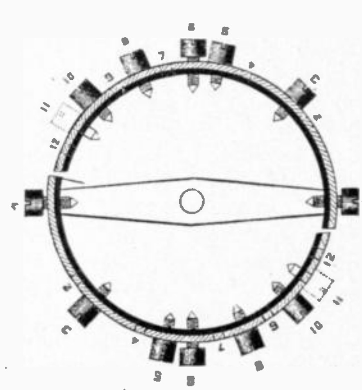


FIG. 5

Every watchmaker who takes pride in putting a watch in shape to keep anything near accurate time should provide himself with some convenient form of apparatus in which any desired degree of temperature could be obtained and maintained, for the purpose of giving watches that had been "knocked out" in this respect a test for adjustment to temperature.

While this matter of adjusting watches to temperature is an important factor in the repairing of watches, there are adjustments to position, isochronism, etc., which are also matters of great importance, and every workman who aspires to a higher knowledge of the art than that necessary to brush off the plates of a watch, peg out the pivot holes or insert a new mainspring, should get a copy of "The Watch Adjuster's Manual," published by *The Keystone*. Personally I have read nearly everything in print on these subjects, and in my opinion this is the best book ever written on high-class horological craftsmanship.—*The Keystone*.

BORING HOLES IN GLASS

Glass is universally conceded to be exceedingly difficult to work when cold, yet its fragile nature often calls for means of repair. It is also desirable sometimes to drill large holes in glass plate, or through a glass column, which is not an easy thing to do with any facilities hitherto developed for such work.

It is well known that turpentine applied to a small drill will enable one to drill through a piece of glass by persistent application and frequent grindings of the drill. This hole will often taper from a larger diameter at the top to a smaller one at the bottom, and besides it is quite impossible to drill two holes of the same size with the same drill. Instrument work of certain classes would be made better also if it were possible to tap threads in the glass of which the base or other parts are composed. In the opinion of the writer the best fluid to be applied to the glass so that the tool will take hold is that of the formula given below. It has been developed after many experiments with different mixtures, and will be found to be superior to anything heretofore known. With a bastard file wet with it, a piece of plate glass may be put into a vise and filed like wood; any other cut of file may be used, but where there is much glass to remove, the coarser the file the better.

For drilling small holes, a brass tube of the diameter of the hole wanted is better than a drill. The tube should be made smooth on the end that is to come in contact with the glass, and charged with carborundum powder, or what is better, diamond dust. In starting the hole a piece of wood having a hole drilled in it of the size of the brass tube should be cemented to the glass, the hole being located over the spot where the desired hole is to be made. A hole should be made in the side of the tube by filing into it with a round file, and it may be turned either by a drill press or by one of the small geared, hand-drill stocks used for small drills. With a small brush dipped into the solution as herein given wipe the hole so that a little of the mixture will run down inside the tube, and onto the glass where the hole is being made, and the tube will be found to enter the glass with surprising ease.

If it is desired to have the edge of the hole sharp where the tube comes through, cement a small piece of glass to the under side of the plate being bored, and when the tube is through, continue the boring until it has entered the lower plate slightly. Glass cut with the diamond will often break unevenly, and fail to fit a window sash; circles cut out for the dials of instruments of the clock class, circles for static electric machines, glass covers for galvanometers, ammeters, and many other instruments are often thrown away, when a touch with a file wet with this solution would save them. It is especially recommended to glaziers to remove the sharp edges of the glass cut with the diamond, which often cut the hands. For boring large holes in plate glass the jig shown in the sectional view, Fig. 1, is very handy, in fact almost essential if correct results are required. It can be easily modified to hold the cutter for boring circular work, such as glass columns or concave surfaces, where circumstances require such variation. The frame is an iron casting having feet *J*, and is bored out to receive a steel bushing *C*, which may be hardened after a central hole is made to receive the shank *B* of the cutter bar. The top of the cutter bar or shaft is squared at *A* so that a bit stock may hold it, or it may be held by the chuck of a drill press. The bottom has a flange and a pilot *L*, which fits in the hole of a small emery wheel *G* of the kind used by toolmakers on universal grinding machines for lapping out small holes.

The lead bushing in the wheel should be cut out on the side that is to do the boring, and the pilot *L* must not go entirely through the wheel, but be cut at least 1/8 in. short of the wheel thickness. The wheel may now be cemented to the cutter shaft by heating it, and also the wheel slightly, so as to melt some gum shellac which has been sprinkled on the top side of the wheel. After it is cold mix up a stiff paste of liquid glue and emery of about the same grade as the wheel, and fill the bottom of the hole *P* even with the wheel. In drying it will shrink slightly, and the paste may be applied again, and until the surface is flush with the side of the wheel.

The feet *J* of the frame have thin rubber *F* (known in the stores as "rubber dam") cemented to their under sides with bicycle tire cement, so that when placed on the glass the jig will not slip around, but can be easily held in any desired location.

The place where the hole is to be made having been ascertained, a ring of putty D is stuck to the glass to form a cup; and after the wheel shaft is inserted in the bushing, the apparatus is placed with the face of the wheel over the spot to be bored, with the feet *J* resting on the glass. Before beginning operations a piece of double-thick window glass *H* is cemented with French copal varnish to the under side of the plate to be bored.

The formula for the fluid to be applied to the tools is as follows:

Pulverized camphor..........2 oz.
Sulphuric ether..........6 drams.

Enough oil turpentine to make a 6 oz. bottle full.

Apply the bit stock to the shank *A* of the shaft, then pour enough of the fluid into the putty cup to cover the lower side of the wheel *G*.

When the wheel is turned it will immediately enter the glass, boring a very smooth and true hole. If a drill press is used, the speed should be slow to avoid throwing the fluid out of the cup or heating the wheel, the last being especially avoided, as all of the constituents of the fluid are very volatile, and it will evaporate quickly if much heat is present.

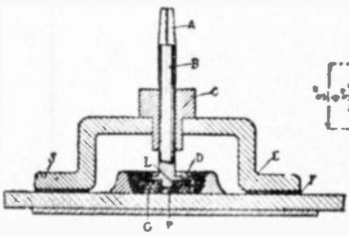


FIG. 1

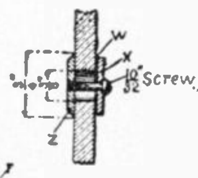


FIG. 2

When the hole is nearly through moderate the pressure, but keep on drilling until the wheel has entered the plate *H* slightly. A slight tap with a hammer will now knock the window glass off, and the wheel and shaft may be removed through the hole. Do not attempt to remove it through the top unless the hole is very clean, or you will pull the wheel off the arbor.

Fig. 2 shows how a cracked plate-glass window may be repaired. At the ends of each crack and where they intersect, a hole is bored to receive a bolt. The nut *Z* of the bolt is made thin, and a rubber washer, made of engine packing, is held against the glass by a washer and screw. The dimensions given are those used some time ago in repairing a store window. The heads of the screws were located inside the store, so as to make it impossible to remove them from the outside. The window is still doing service.—*George J. Murdock, in the Scientific American.*

Occasionally we meet with people who are like some of the modern bedsteads—all brass.

WIRELESS AROUND THE WORLD

The Imperial Press Congress held in London passed a resolution urging upon the governments of Great Britain and her colonies the desirability of establishing a chain of wireless telegraph stations between all British countries for the cheapening of rates and the protection of the British mercantile marine. Mr. Marconi, who was called upon to speak, said it would be of great advantage to ships and shipping if routes to the East were provided with stations, just as were the western coast of Europe, Canada, the United States and Great Britain. He would be very glad to give any representatives of the conference or the committee or the government concerned every facility to be present at the stations established, so that they might be able to ascertain the possibilities of this wireless communication across the Atlantic. The cost of two stations capable of communicating over a distance—already found to be practicable—of 3,000 miles would be about $250,000 for each station. Of course, that was subject to conditions, local or otherwise, which might increase the cost. He was of opinion that it might be possible in the near future to communicate over a distance of 6,000 miles and perhaps even more. He was prepared to say that he would take a limited amount of press work across the Atlantic at five cents per word, when the stations were completed, and that he hoped to take 15,000 to 20,000 words a day. If the amount of press work by this system were considerable, his company would be prepared to give a service at four cents per word from Canada to England. The present speed across the Atlantic was twenty-five words a minute. They hoped to introduce a duplex system, and that would mean fifty words a minute, and perhaps further improvements would increase that number. He was not a cable expert, but he thought there was a general belief that fifty words a minute would be about the limit across the Atlantic. Five wireless stations would, of course, do five times the work of one station, and with the latest improvements, there should be no fear of interference. There was, Mr. Marconi added, a very interesting point connected with communication above 6,000 miles. It was that when the equator was passed the waves might converge again, and it might be that messages would be received at the Antipodes much easier than if they were half way.

The first wireless messages across the Atlantic were sent from the Canadian station at Table Head, in Cape Breton, in 1902. This station was afterwards removed to its present site, five miles inland, and there greatly enlarged. Ever since 1902, Mr. Marconi has been conducting experiments and making new discoveries and improvements until, at the present day, wireless telegraphy across the Atlantic, over a distance of two thousand miles, is an assured success. In the early days of the invention, it was considered a great feat when wireless telegrams were transmitted across the English Channel. Mr. Marconi made such rapid improvements in his system, however, that in 1900, he thought he had sufficient data to enable him to design a new station of sufficient power to bridge the distance separating the Old and New Worlds. The Poldhu Station was completed in 1901, and Mr. Marconi received the first signals across the Atlantic from this station in Newfoundland, towards the end of that year. A station was therefore constructed in Canada, on the invitation of the Canadian Government, and by the end of 1902, it was found possible to transmit from this station and receive the messages so transmitted at Poldhu, in Cornwall. The station at Poldhu, not being so large as the Canadian station, was unable to send signals of sufficient strength to be read in Canada, and it was therefore enlarged.

Many curious phenomena previously unknown, were discovered during the early experiments in transmission of signals across the Atlantic. It was found that messages could be read by night, while no signals could be read at the receiving station by day. It was found also that the strength of signals varied greatly from minute to minute, and until these difficulties had been overcome, it was useless to attempt to open the service for the transmission of paid messages, although early in 1903, a short press message was sent daily, to The London Times, until a breakdown in the plant occurred, which, perforce, put a stop to this also. From 1903 to 1907, Mr. Marconi devoted practically his entire attention to investigating the causes of the variation in the strength of signals and devising means for overcoming the trouble. His investigations led him to the conclusion that the existing stations were not suitable for the work required of them, and therefore, the Canadian station was removed and greatly enlarged, and a new station built in Ireland. Experiments were then continued, and many subsidiary improvements made in the plant, whereby safety and trustworthiness were assured until, after exhaustive tests, extending over a long period, it was found that the system was thoroughly trustworthy, and it was decided to open the stations for press traffic, which was started on Oct. 17, 1907. On Feb. 3, 1908, the service was extended to private and business telegrams between Montreal and London. The number of words transmitted during the past year is in the neighborhood of 300,000.

Although 300,000 words have been transmitted by wireless, only two mistakes have been reported, it is said, which can be attributed to the wireless system; other mistakes have occurred, but these, in every case, except on these two occasions, have been traced to the land lines.

Since the opening of the wireless service across the Atlantic, Mr. Marconi and those associated with him have been conducting experiments with a view to increasing the speed of transmission. At the present time, the average speed of sending is 24 words per minute. Theoretically, there is no limit, as there is in the case of cables, to the speed at which messages can be sent, and it is expected that the speed will shortly be increased to 60 words per minute. Moreover, Mr. Marconi has lately devised, as explained before the Press Congress, a method of duplex wireless telegraphy which, when installed on this service, will again nearly double the speed of working, and which will eventually mean a further reduction in the rates charged. The Marconi Company has to compete against sixteen cables across the Atlantic, whose service is, without a doubt, the best cable service in the world, and whose cable rates are the lowest for the length of cable laid. If, therefore, wireless telegraphy can effect a reduction in rates between Canada and England in the face of such efficient cable competition, where the cable service is not so efficient, the value of wireless telegraphy will obviously be infinitely greater.

As it has been shown that wireless telegraphy can be worked with success over distances up to two thousand miles, and although Mr. Marconi and those who have assisted him in his experimental work are of the opinion that with slight extra initial expense, considerably greater distances could be bridged successfully, a network of world-wide wireless connecting all British possessions by means of power stations is herewith described, none of which will be required to transmit or receive over as great a distance as separates the existing successful transatlantic wireless stations, and will define a scheme whereby all British possessions could intercommunicate and communicate with the centre of the empire, at a cost of two cents to sixteen cents a word, in the case of the most distant British possessions, and at the same time show that even this extremely low rate could be still further reduced to a uniform penny a word throughout the empire.

The route from England to Australia would be as follows: England to Malta (1), Malta to Cairo or Alexandria (2) (as far as distances are concerned, the Malta station could be omitted), Cairo to Aden (3), Aden to Bombay (4), Bombay to Colombo (5), Colombo to Singapore (6), Singapore to Perth (7), Perth to Adelaide (8), Adelaide to Sydney (9), Sydney to Wellington, New Zealand (10).

The route to China would be from Singapore to Hong-Kong (11).

To Africa, there should be two routes, one on the east and an alternative route on the west coast. On the east coast, the route would be from Aden to Mombasa (12), Mombasa to Durban (13), Durban to Cape Town (14). On the west coast, England to Bathurst (15), Bathurst to Sierra Leone (16), Sierra Leone to St. Helena (17), St. Helena to Cape Town (18).

An alternative route to India and Australia connecting these two great countries with Africa could also be laid by the erection of stations at Mauritius (19) and Nelson Island (20). The connection with the western hemisphere has already been effected by means of the existing station at Glace Bay. Another station should be erected at Montreal (21) to communicate direct to the West Indies (22), which islands should all be connected together by means of short-distance stations of small power. Yet another station should be put up in British Guiana (23), where the existing cable charges are 7s per word, and another station in Canada at Vancouver (24). Mr. Marconi expects to be able to communicate direct from the present Glace Bay station to Vancouver, in which case it would be possible to have another link to the east by a larger power station at Vancouver communicating direct to Hong Kong. But this latter distance is beyond the range to which we are at present confining ourselves, although it will undoubtedly be possible to bridge this distance in the near future. Other stations of moderate power could be erected at places such as the Gold Coast, weaving the smaller portions of the empire into the network.

Marconi states that a station of a range of two thousand miles can be erected and equipped for $250,000 or $275,000, and operated for a sum of $50,000 per annum, any earnings over which would be gross profit. If the British Government and the governments of the great self-governing colonies and dominions were to convince themselves of the practicability of such cheap telegraph rates they might be willing to obtain the benefits that would accrue from a two-cents-a-word service, and enter into a contract for the erection of such stations, or agree to pay the actual cost of construction, plus a fair percentage profit to the contracting company, and allow the company either $50,000 per annum per station and the tolls collected at two cents a word, or, say, $100,000 per annum, the Government retaining the tolls. To equip and erect all the stations described, twenty-four in number, would entail an outlay of $6,600,000, a small sum to provide an imperial two-cents-a-word telegraph rate; the annual outlay would cost the British and Colonial governments collectively $1,250,000 a year if the contracting company were to receive the tolls as their profits, or, say, $2,500,000 per annum if the Government retained the tolls, or $1,250,000 per annum if the Government worked and operated the stations themselves. To equip the most important stations, fifteen in number, neglecting small dependencies and alternative routes, would entail an initial outlay of $4,125,000 and an annual outlay of $750,000.—*Boston Transcript.*

Simple Phoneidoscope

An extremely simple form of phoneidoscope can be made by bending the forefinger and thumb so as to form a circle, and then drawing a soap film across them. By turning the wrist the angle made with the direction of the light can be varied; a motion of the elbow alters the distance from the mouth, and the tension of the film can be varied by moving the thumb and forefinger.

On singing or talking close to this film, when adjusted to the proper tension and position, the most varied and beautiful rainbow-colored figures appear, which may be reflected from the film directly on a screen.

The cause of these colors lies in the phenomena connected with the interference of light waves striking the screen. By the air vibrations induced by the voice the film is set into undulations which vary its thicknesses. In transparent films as thin as these, the part of the ray that is reflected from the first surface it strikes interferes with that part of the ray that is reflected from the further surface of the film, after passing completely through it. This interference neutralizes a part of the color of the composite white light, leaving the remaining light colored when reflected. Since the different portions of the film are of different thicknesses the color of the ray that each part will remove in this manner is different, and hence the remaining light will be varied over different parts of the film.

Robt. E. Bradley.

MACHINE SHOP
THEORY AND PRACTICE

Edited by OSCAR E. PERRIGO, M.E.

THE OPPORTUNITIES OF THE APPRENTICE

In the previous issue the effort was made to classify the young men who have composed the machine shop apprentices in former years, and up to the present time; to show the various motives which actuated them in deciding to become apprentices; and their education or previous experience as tending to fit them for their future work. This presented in more or less detail the apprentice's side of the question.

This educational question was also treated from the school point of view, showing, to some extent at least, the relation of the schools to the apprentice, and his educational preparation for practical shop work. In this connection the curriculum of the Manual Training School and Mechanic Arts High School was considered as to its arrangement, operation and results in preparing the apprentice for a chosen trade.

The third and more practically important portion of the subject was that which considered the question from the standpoint of the manufacturer. To him the subject of an ample supply of properly skilled labor is a vital one and his interest in the kind and quality of the apprentices in his shops, and the quality of their previous education, is a matter of much importance.

These questions have always been subjects of a great degree of interest and under the present conditions of manufacturing, with the interchangeable system so universally in use, and the "all 'round" machinist of former years such a rare man and in such great demand, the question of how this great need is to be supplied in the future is a very serious matter.

It is the purpose of the present article to consider these questions and the relations existing between the apprentice and the shop; between the apprentice and the manufacturer, or employer, and the regular routine of shop work, with special reference to the opportunities of the apprentice for advancement along regular and special lines, since both of these must be considered, although the modern idea of specialization finds far the most favor with a majority of well-informed men.

In this age of specialization the aim of many intelligent apprentices is to have their course of instruction in practical work in the shop so shaped or directed as to accomplish two objects, namely:

First: To learn so much of the use of hand tools and the operation of general "machine tools" (regular machine shop equipment, as lathes, planers, shapers, milling machines, etc.), as may be necessary for a general knowledge of machine shop work.

Second: To obtain in much detail the instruction necessary, and the practical use of tools, machines, operations and processes constituting some quite well-defined specialty of manufacturing work.

These various specialities in the usual work of the manufacturing machine shop may be classified as follows, viz.:

First. Tool Making. This is easily classed first, and is generally aspired to by the more ambitious apprentices.

Second. Automatic Screw Machine Work and Turret Lathe Work. This class of work is almost as distinct a specialty as that of tool making.

Third. Milling Machine Work and Gear Cutting. This has become a very important branch of machine work since the scope of milling machine work has been so greatly widened, and since spiral gears have been so universally used.

Fourth. Lathe and Planer Work; Shaper and Slotter Work; Boring Mill and Drill Work. While every machinist is supposed to know the principal points in relation to this class of work it becomes one or more specialties with foremen when in charge of these different departments.

Another class might be added to the above including those who intend to qualify themselves as mechanical draftsmen and plan to obtain a practical knowledge of shop work as a prerequisite.

Let us consider for a few moments what this classification means to the young men just starting out in a mechanical life with the desire and ambition to achieve success. In former years he was simply to become a machinist, and was rated according to his general ability to handle whatever kind of work came his way. To be sure he was a much better workman on some classes of work than on others. Sometimes this fact led to his advancement, and with the opportunities for better work he secured a broader and more varied experience and became a more useful man and a better mechanic. Again, the change to a different class of work led to his success in some special direction. This last condition was the germ which in due time produced the special classes referred to above, and many others of more or less sharply defined development.

But in a general way he was what we usually refer to as an "all 'round machinist," that is, one capable of doing any sort of machine shop work that was given him, and in many instances making his own tools with which to do the work. His real usefulness was indifferently appreciated until, with the advent of the era of specialization, the number of these men grew less and less, until at the present time there are but few of them to be found and their broad range of abilities are highly appreciated and much sought after.

The interchangeable system of manufacturing having been largely instrumental in producing the classification of specialties described above, it will be of interest to the young apprentice to get a practical idea of the requirements, the duties and limitations to which these several classes are subject, in order to enable him to form some definite conclusion as to what class he is best fitted to strive for, or to which his education, experience and inclination render him the best adapted.

It will, therefore, be profitable to enter more particularly into the requirements, the work and the routine of each of these classes, so as to give the apprentice a correct conception of the matter from the viewpoint of the employer and manager of men and their work in manufacturing operations.

To be a good tool maker has been a popular wish of the ambitious machinist, and few have allowed to pass the opportunity to work up to this lucrative and much esteemed position, in whatever class of manufacturing work the shop might be engaged in. However, the requirements of such work are many and important. The man must be bright, intelligent, ingenious and accurate. He must have a fair knowledge of mathematics; be able to reason correctly from cause to effect; to know most thoroughly the theory and practice of handling all hand tools; to know the use, the capacity and the limitations of all machine tools; and to be able to make readily and accurately the finest measurements; to read drawings quickly and correctly. He should be able to make good and accurate detail drawings of all work upon which he is engaged; he should know the component parts and their percentages of the different metals he handles, particularly steel; he must be well versed on the heat treatment of the different classes of steel; so as to be able to properly "temper" all the tools and the various parts of dies, jigs, fixtures, etc., that it is necessary to be of hardened steel.

To do these various classes of work successfully, requires not only unusual intelligence, but the ability to apply that knowledge in a practical manner to a great many very necessary branches of the mechanical work which the tool maker is sure to encounter in his regular routine work. At the same time that the requirements are many and the responsibilities great the work is of a high class and the salaries quite attractive; but to reach such positions will usually require years of continuous, patient application and hard work.

Automatic Screw Machine Work covers the making of a great many different pieces beside screws, although this particular class includes a great variety of forms.

The automatic screw machine is a limited and limiting title for a machine whose ancestor was designed for the special purpose of automatically making screws, which were produced with a degree of accuracy not previously attained, and with an efficiency and economy unheard of at the time.

With the capacity to make all sizes and varieties of screws it was but a step in the process of development to so arrange the machine and its tools that it would produce a great variety of small cylindrical parts, such as studs, shafts, collars, ornamental parts, and so on, that could be made from a bar fed into the machine, automatically formed and the completed piece cut off.

To successfully operate these machines requires a good mechanic who knows thoroughly the construction, operation and requirements, the capacity of the machine as well as its limitations.

These requirements naturally appealed to and attracted a class of good and ingenious as well as ambitious machinists who saw in this line of work excellent opportunities for the exercise of their ingenuity and ability to plan new lines of automatic machine work, and the reward of a good salary for its successful accomplishment. It offers the same inducements at the present time, although special adaptability and good training are prime requisites to success.

The Turret Lathe is in the line of development of the automatic screw machine with the important difference that while the latter forms the required piece from the end of a bar of iron, steel or other metal fed in through the main spindle, the turret lathe is designed to handle separate pieces, such as cast, forged or punched pieces, usually, but not necessarily, of circular form.

In both these machines a series of special tools are made, one or more for each of a series of from two to six operations, and sometimes several tools to complete the required number of cuts forming a single operation; the tools being mounted both in a revolving turret and in "cross slides" analogous to the slide rest of an ordinary lathe.

From the nature of the work required to plan operations, make tools, "set up the machine," and look after its operation successfully, it will be seen that a good mechanic with original ideas and ingenuity is a requisite for the care of the automatic screw machine, and therefore furnishes a considerable field for the apprentice who aspires to so understand his trade and its specialties as to command a good salary.

The work of the Milling Machine has greatly increased and its scope broadened during the past few years, until a considerable portion of the work formerly done on the planer and the shaper is now more accurately, efficiently and economically handled on the milling machine. This is particularly the case with many long cuts formerly made on the planer, requiring a number of different settings of the tools, even on double or quadruple head planers, which is now done on a long milling machine provided with a gang of mills, making a roughing and a finishing cut.

For instance, by the use of this machine the entire top surface of a lathe bed having four Vs is formed by a single cut, a second cut finishing the work ready for scraping. This work upon a planer would require no less than twenty-two cuts, and at least half that number of changes of tools.

The milling machine has a very large range of different operations, many of which cannot be done as well or as economically upon any other machine in the shop. With the advent of the modern universal headstock, with which nearly all the first class or universal milling machines of the present day are fitted, all classes of gear cutting can be done, while the popular spiral gears cannot be cut on any other machine unless it is one designed for this special work.

Hence, it is that the expert milling machine man who understands thoroughly the capabilities and adaptability of the machine through all its broad range of work, and the making and using of the large variety of cutters required, as well as the design and construction of this most useful and efficient machine, is considered as one of the first-class machinists, and as such is entitled to first-class pay.

While Gear Cutting is usually a milling job, it is not always so, since the gear planer works on quite a different principle; while the gear shaper operates on still another method, and requires not only very different tools but quite a different experience on the part of the operator from that with the revolving toothed cutter.

Thus there are in reality three quite distinct classes of gear-cutting machines, neither of which are adapted to cutting spiral gears, namely: the gear cutting-machine carrying a revolving cutter, the gear planer and the gear shaper.

The first class is practically a milling machine provided with either a very large indexing plate, or a geared indexing device. The second and third classes are usually considered as gear-generating machines, since they are so designed as to automatically generate a proper gear tooth curve upon each gear cut. The second class performs this by a single pointed tool and the third class by a circular toothed tool used as a planing tool, in the operation of which both the tool and the gear blank very slowly revolve during the process of cutting.

To become an acknowledged expert on these classes of work is a matter of much credit to a young man and insures him lucrative employment in the regular gear manufacturing or cutting shop, as well as in many of the general machine manufacturing plants.

The general machine shop work upon the Lathe and Planer, the Shaper and Slotter, the Boring Mill and Drilling Machines are well known and need not be particularly described. Attention should be called to the fact that they are essentially necessary departments in all machine shop plants and that therefore there is a widespread and general demand for expert men along these lines who are well informed on general machine shop work and have the ability to handle men as foremen or assistant foremen.

While there is nothing especially brilliant in the career of such a man, he is exceedingly useful and valuable to the manufacturing organization, whose successful operation would scarcely be possible without him. Therefore this class of work offers good opportunities for the ambitious apprentice who desires to confine himself strictly to the routine work of the ordinary machine shop.

Hand work, such as filing and fitting, is at the present time more in line with the work of the assembling and erecting departments and in the usual work of the manufacturing plant, and while the work cannot be very clearly defined or classified, it frequently develops specialties requiring a considerable degree of mechanical skill and good judgment. Men in charge of this class of mechanical work frequently receive quite liberal salaries.

There is another and very important series of specialties which are assuming additional prominence each year, and which are the natural outcome of the refinements of manufacturing details and the strife for accuracy, efficiency and economy, not only in the manufacturing operations themselves but in all subsidiary operations, such as handling and transporting materials, accounting for the cost of material and labor, the general expenses incident to manufacturing operations and all similar matters necessary for successful work.

These specialties include the superintendent's assistant who makes out shop orders and starts them on their way through the shop; the store-keeper, who has charge of all material and issues it to the manufacturing departments; the production engineer's assistant, who traces the orders through the works; the transfer clerk, who controls and records all transfers of work in progress from one department to another; the time-keeper, who has charge of the keeping and the distribution of all labor upon both productive and non-productive work; the time-study man, who makes an exact and analytical study of the time of every machine or hand operation, and suggests changes and improvements for the increase of machine and man efficiency; the draftsman, who designs and develops the shop operation sheets for the sequence and direction of shop operations; and inspectors, who inspect the work after each operation, or series of operations, before it is allowed to be transferred to the next department; then the production engineer, who has charge and direction of all these various classes of manufacturing operations.

In addition to this the cost system men follow up all these operations in very minute detail, recording all matters of material and labor, shop expenses and every item of overhead expense incident to the running of the shop.

In former years work of this kind did not receive the strict attention that it does at the present time and such records as were kept were made by clerks who usually knew little or nothing of mechanical matters. Under the present conditions of strong and active competition in manufacturing operations, when the workmen's time is calculated on machine operations to fractions of a minute and costs to hundredths of a cent, and every effort made to eliminate every useless mechanical detail, the men engaged in the work as above described must be, first of all, men of mechanical ideas, methods and ability.

Hence, the introduction of modern systems and their refinement to such minute conditions has opened vast fields of effort and usefulness to ambitious young men, in which the rewards in the holding of an interesting and responsible position, at a good salary, are much better than the usually slower process of becoming an expert in some of the classes of strictly machine work as above described.

Again, the prospect for advancement along these lines is much better, owing to the facts that: first, the field has not yet been so thoroughly covered; hence, there is much less competition. Second, there is much greater need for this class of service than ever before. Third, there are comparatively few young men who are fully aware of the present conditions and opportunities within their reach. Fourth, young men are liable to find it easier to "get into ruts," to proceed along the lines of least resistance, rather than to go to work energetically with a well-defined purpose and ambition to make the most of the opportunities presented.

Thus we find easily contented young men quite satisfied to plod along month after month and year after year, developing at best but mediocre ability, and receiving a salary in keeping with it, who might with more ambition and a desire to get ahead in the world, make for themselves good, responsible and well-paid positions. This is a great mistake and one that every man should avoid. It is his duty to himself to make the most of his opportunities, to take up some line of work where energy and ability is needed, and then, regardless of obstacles, push on to ultimate success.

A Joke on the Cigarette Smoker.

If your friend smokes cigarettes and rolls them himself, you may have some fun at his expense by procuring some of the paper he uses and passing it slowly through a thin, blue spark from an induction coil that is operating without a condenser on the secondary circuit.

A short, hot spark would ignite the paper, but a long, thin one will merely puncture very small holes through it. When your friend makes cigarettes from this paper he will find that no matter how many times he lights them they will invariably go out, the air coming in at the sides rather than at the end.

Robt. E. Bradley.

To Prevent the Steaming of Envelopes.

Steaming of envelopes can be effectively prevented by moistening one flap with a strong solution of yellow prussiate of potash, and then coating with mucilage and allowing to dry. The other flap is moistened with a solution of ferric alum, and dried. If steamed, after sealing, the water will saturate the paper and bring the two solutions into contact, causing a bright stain of Prussian blue.

Another device is that in which alternate lines are ruled on the lower flap with solutions of the yellow prussiate of potash and with ferric alum. Steaming will moisten the salts on these lines causing bright lines of Prussian blue.

Robt. E. Bradley.

WIRELESS TELEGRAPHY

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

THE INTERFERENCE EFFECT IN WIRELESS TELEGRAPHY

JAMES M. MURDOCK

In the extended discussion of the interference problem in radio-telegraphic working, which has found popular exposition in the daily press because of the proposed restrictive legislation relative to the future control and operation of wireless stations in the United States, two points have been especially prominent: First, the emphasis which has been placed almost universally upon the idea that regulation of emitted wave lengths would render the effect negligible; and second, the misapprehension arising from the prevailing impression that "close tuning" of receptive circuits is an absolute interference preventer. How far these conceptions are in error may be seen from a consideration of some generally overlooked aspects of the problem.

Interference consists of the interruption of the reception of telegraphic messages. In wire line working, the effect would be noted upon the introduction of a private current and is had on occasions of so-called "magnetic storms." In wireless working, it is had when the receptive circuit is sensibly influenced by the incidence of actuating electro-magnetic waves other than those which it is desired to convert into an intelligible message. It may be had when vagrant wave trains, originating from physical phenomena, such as lightning or solar radiation, impinge upon the receiving circuit; or, when wave forms emitted from the energized antennæ of other wireless stations are incident during the reception of a message. For present consideration, the atmospheric interference may be neglected, since the production of such waves is beyond the control of man. In the second instance, an examination of the problem is possible, since the propagation of the waves is due to devices operating in accordance with known principles.

In the production of wave forms in any medium, certain characteristics are developed. Thus, when a stone is dropped into a body of water, observation shows that the wave form ensuing is concentric; that the wave progresses at a regular speed; that it has a certain elevation and depression with relation to the normal plane of the water; that such elevation and depression decreases as the distance from the point of disturbance increases. If a second stone of larger volume be introduced with greater force, the same main characteristics will be observed, with certain enlargements due to the differentiating properties of the initial cause of the disturbance. In general, then, it may be stated that wave forms produced in any medium possess the characteristics of amplitude, frequency and continuity or diminution.

Considering the action of a single string in a piano, we are aware that it produces a sound wave in the air when a force capable of initiating vibrations of the string itself is applied. Experiment will show that the volume of sound produced depends upon the latitude through which the string vibrates; that the pitch of the musical tone depends upon the frequency with which the string vibrates in a given time; that the sound dies away with greater or less speed, depending upon the varied conditions inimical to continued vibration; that the string vibrates either as a unit, or in parts; and finally, that the string may be set in vibration by the production, in its vicinity, of a musical note, complying in frequency of sound waves, with that frequency with which the string itself naturally vibrates.

Now, in the production of electromagnetic waves, it will be found, that the oscillatory circuit will emit most efficiently a wave which is natural to that circuit; that the wave form has an amplitude dependent upon the impressed force and the physical make-up of the circuit; that the wave will suffer diminution in amplitude under certain conditions; that the circuit may oscillate as a unit or in integral ratio of the fundamental period; and finally, that the interposition of a like circuit in the vicinity of the emitted waves will produce therein oscillations similar to those produced by the original circuit. The latter effect, called resonance, from the similar acoustic effect, is the basis of all "tuning" of receptive circuits in radio-telegraphic working.

If a pure, sustained musical note be sung into a piano with undamped strings, that string whose natural frequency period coincides with the frequency of the note sung will be set into vibration and will produce an audible tone; but, if a violent shout is uttered in the vicinity of the piano, presuming that the predominant tone of the shout is that of the note previously sung, vibrations will be initiated, not only in the string which most closely agrees with the wave frequency, but also in other strings. In some, because of minor agreement in frequency with some of the waves composing the shout; in others, because the air agitation was of sufficient *intensity* during its brief duration, to set up forced but unsympathetic vibrations in the strings, with periods differing slightly from the fundamental periods of the original sound.

Correspondingly, a circuit in wireless telegraphic working, which is "tuned" to respond to electro-magnetic waves of a certain length and its dependent characteristic, frequency, must necessarily record, by sympathetic oscillations, the passage of a particular wave. At the same time, it should be, and is, susceptible to those impulses, which, by reason of intensity or accord in some dominant element of their composition, are liable to initiate "forced" oscillations.

The precise syntonisation of a wireless transmitting circuit, with due reference to the period which is fundamental for that circuit, would naturally predicate the construction of a receptive circuit, sensible only to the impulses of the particular transmitting instruments, which operate in syntony. Consequently, from this principle have been evolved those efficient combinations which do actually negate the effects of interference arising from the operation of other transmitting apparatus with a wave length different from that to which the receptive circuit is normally responsive; but, by the very same principles, it is seen that beyond the responsiveness of the "tuned" receptor to a particular wave, there still is the possibility of producing, through varied elements of other incident waves, forced vibrations which are recognizable with the natural period.

In 1741, a watchmaker named Ellicot placed two clocks on a rail. One was going; the other was not. Returning in a short time, he was surprised to find the second clock ticking away. It appears that the pendulums of both clocks were of the same length, and that the quiet, regular shocks of the first clock were imparted to the second through the rail and the period agreeing with that natural to the pendulum, it was set in vibration. Now, if Ellicot had given the rail a single violent blow with a hammer, it is entirely possible that he would have set the clock going.

Still further, it is commonly known that a swing may be set moving with very little effort if the force applied is exactly timed to the natural period of the swing. Yet a single violent impulse will produce a similar result.

And again, if a string at rest is brought into the vicinity of a vibrating string, the second will produce no effect in the first if they are of different lengths and the vibrations of the moving string be sustained and of small amplitude. But if the impulse is sudden, of great intensity and quickly decadent, a tremor will be felt in the first string, though its period is totally dissimilar to that of the moving string. It may be noted in the latter case that at a distance the effect would be negligible.

Suppose the existence in close proximity of two wireless stations, operating with dissimilar wave lengths. Suppose that the receptive circuit of the first is adjusted in capacity and inductance for a wave which is 10 per cent. longer than that which the second station is transmitting. On the theory of lack of resonance, there is reason to believe that the receptor could not be influenced by the production, even in the immediate vicinity, of waves which are unlike those to which it is suited to respond sympathetically. But, as suggested in the analogous cases of the pendulums and the strings, the absolute freedom of the receptive circuit from *any* oscillation would depend, not only on the fact that it was tuned to respond to a certain wave, but, incidentally, on the nature of the impulse which impinges. If the sending station were emitting a series of waves, none of which singly possessed sufficient intensity to perceptibly affect the receptor, there would be no interference; but, if the sending station projected a train of impulses of great and sudden intensity and of quick decay, the receptor, under the preceding conditions unaffected, would record the passage of the impulse by "forced" but unsympathetic oscillations.

The elements which must be taken into consideration are, therefore, distance, intensity and decay or damping. The value of "tuning" as an interference preventer must necessarily depend as much upon what may be accomplished with transmitting circuits, as with receptive apparatus. Any advance towards the syntonisation of transmitting circuits to produce long continued wave trains of small intensity, is an advance towards more freedom from interference. Any continuation of strongly damped, high intensity radiation means the continuation of interference, even though the receiving circuits be the best possible.

Legislation, to be effective, must prescribe regulation for all elements of the transmission of ether waves, and very little or none for the reception. It does not seem a matter of strict necessity that there should be any limitation of the number of wireless equipments in a given area. That would be a remedy, if the facts were otherwise, but when, by means of finely syntonised circuits in both transmitting and receiving apparatus it has been experimentally proved that messages may be sent and received on the same aerial, it would seem possible that an indefinite number of stations might operate in a given area without interference if certain prescriptions relative to transmission were followed.

In conclusion, let me append the following excerpt from an article by Professor J. A. Fleming, entitled "The Scientific History and the Future Uses of Wireless Telegraphy." It is taken from the *North American Review* of May, 1899, and is interesting not only because of the suggestion with regard to interference in wire communication, but also for the remedy proposed for the wireless effect: a somewhat aged hint of the remedy which is now (1910) proposed for the interference problem in the United States.

"It has been contended that this method of telegraphy has no utility, because each receiver can be disturbed by vagrant ether waves made in the neighborhood. This objection, however, has little force. Ordinary telegraphic communication with wires could also be upset if mischievous persons cut wires, or sent private electric currents into them. Public opinion and a few legislative enactments will, however, be sufficient to meet this supposed difficulty."

The "supposed difficulty" is said by some to be a very real and vexatious one here in the United States at least. The business-like way out of it seems to be legislation; but it should be remedial, not restrictive legislation, based on the scientific facts of the problem, not on the necessity of finding an easy way to stop interference. Legislation presenting a monopoly in wireless communication, either to the government or to commercial companies, is not a solution; but the solution will lie in such regulation as will permit, with due regard to the legal rights of all, the establishment of wireless stations by all who care to observe the prescriptions.

ELECTRICAL MEASUREMENTS FOR AMATEURS

ROBERT E. BRADLEY

Making measurements of electricity does not consist entirely of measurements of the amount of pressure or current in a circuit. The process is much more extensive than this, and embraces the measurement of resistance, power, induction, magnetic flux, etc. In other words, under the title of electrical measurements may be included a great variety of tests in electricity and magnetism, many of which are of such great importance that it may be said that the very science itself depends upon them for its existence.

Ohm's Law.—The corner-stone of the science of electrical measurements rests upon a true knowledge of Ohm's Law. As far as this is concerned, Ohm's Law presents itself first in the familiar form so well expressed by the statement that "the current is proportional to the electromotive force and universely proportional to the resistance." Compactly expressed, it is as follows:

To get volts multiply amperes by ohms.

To get amperes divide volts by ohms.

To get ohms divide volts by amperes.

Illustrative Problems.—To illustrate these applications the following cases are given: to find out how many volts are required to send 10 amperes through a resistance of 100 ohms. In this case the volts are to be found; and the two values given must be multiplied together.

$$\text{Volts} = \text{amperes} \times \text{ohms} = 10 \times 100 = 1{,}000$$

Next, to find out how many amperes will pass through a lamp taking 110 volts, whose resistance is 220 ohms:

$$\text{Amperes} = \text{volts} \div \text{ohms} = 110 \div 220 = \tfrac{1}{2}$$

A physical fact to be kept in mind here is that an incandescent lamp has a high resistance when cold and a much lower resistance when hot. A resistance test would show that the lamp when cold equals 450 ohms, while at incandescence it falls to 220 ohms.

Next, to find the resistance of a coil of wire which takes a current of 2 amperes at a pressure of 110 volts:

$$\text{Ohms} = \text{volts} \div \text{amperes} = 110 \div 2 = 55$$

These are the simplest illustrations of Ohm's Law as employed by electrical workers all over the world. It undergoes other changes in alternating current theory, because of the fact that additional influences are operating besides those ordinarily appreciated. The above forms, while true, would therefore be inapplicable to circuits carrying variable currents.

Ohm's Law for an Instantaneous Current.—When a current is turned into a circuit for an instant and turned off, or when a current is first sent through a circuit, the current for a short period of time is not exactly equal to the volts divided by the ohms. There seem to be other influences at work which partially arrest the free flow of current. It cannot be said that this influence is due to the resistance of the wire, because if this only were the case, Ohm's Law would hold true in every sense of the word. The difficulty, however, is not so much inside the wire as outside of it. The extent of the influence playing upon the outside of the wire causes the trouble. This, it seems, acts in such a manner that a current cannot be instantaneously sent into a wire at its full strength; neither can it be instantaneously cut short. The wire possesses the power of developing, through this external influence surrounding it, an electromotive force of its own.

When the blacksmith strikes the anvil, the hammer flies back. In a sense, when a current strikes a circuit, the circuit strikes back. The sound may be absent, and there may be no visible signs of this reaction, but it is always there. From a scientific standpoint, it is stated that the magnetism around the wire, which surrounds it when a current flows, momentarily develops this counter acting influence. It acts against the incoming current, checking it, and naturally only permitting it to rise to its full value in a certain period of time; or it acts with retreating current when the circuit is opened, augmenting its pressure at the last moment. It had been noted for some time, before an examination of the conditions had been made by eminent physicists and mathematicians, that rapidly changing currents did not seem to flow in obedience to Ohm's Law. Neither did Ohm's Law, as then understood, coincide in its results when applied to those obtained with a current turned on and off rapidly. The fact that the current took an appreciable time to rise to its full value and did not immediately cease in a circuit opened and closed, gave room for thought. It soon became evident that the simple form of Ohm's Law would not apply to instantaneous or alternating currents. Helmholtz interpreted Ohm's Law in a new form, in which time is considered, and the influence external to the wire called self-induction. He states that the current is equal to the electromotive force divided by the resistance, as given by Ohm himself, but what he adds is true for the value of the current *at any instant*, or

$$C = \frac{E}{R}\left(1 - e^{-\frac{Rt}{L}}\right)$$

where C = current in amperes
E = pressure in volts
R = resistance in ohms
t = times in seconds
L = inductance in henries

and where e, the base of the system of natural logarithms = 2.7183.

To illustrate, let $E = 100$ volts, $R = 20$ ohms, $L = 2$ henries, $t = 5$ seconds. Then e with its negative exponent becomes e with the exponent minus one-fiftieth, which is practically equal to zero. This would leave $C = \frac{E}{R}$, or nothing to subtract. When the time during which the circuit is closed is prolonged, as in this case, to 5 seconds, the simple form of Ohm's Law is left to apply.

Form of Ohm's Law for Alternating Currents.—From the above form of the law another interpretation has been obtained, which is in a more practical form than the last. In this formula, the effects of self-induction and the frequent changes of the current are considered, so that simple calculations can be made. When a current is started in a circuit, at that instant all of the disturbing effects transpire whether the current is continuous or alternating. If the current is alternating, the more rapidly it changes its direction in a second, the more of this reaction takes place in the circuit; in fact, the extent of this impeding influence is given as follows:

$$\text{Impedance} = \sqrt{R^2 + (2\pi n\ L)^2}$$

i.e., Impedance=

$$\sqrt{(\text{ohms})^2 + (2 \times 3.1416 \times \text{frequency} \times L)^2}$$

To illustrate: what is the impedance of a circuit whose resistance = 5 ohms, inductance = 2 henries, and the frequency of 100 cycles (or alternations) per second?

$$\text{Imp.} = \sqrt{5^2 + (2 \times 3.1416 \times 100 \times 2)^2}$$

$$= \sqrt{1,577,561} = 1,256$$

The comparison of the effect of the resistance of 5 ohms and the effect of the impedance in total shows that the resistance may be completely disregarded when the frequency of an alternating current is high or when the self-induction of the circuit is high, *i.e.*,

$$C = \frac{E}{\text{Impedance}}$$

If there is no frequency, the second term under the square root sign disappears (because it is multiplied by 0) and only $\sqrt{R^2}$ is left, which equals R. The three forms of Ohm's Law as given by Ohm, by Helmholtz, and with respect to the false resistance or impedance, all become transformed into Ohm's original form when the time is prolonged in one case, and the frequency or inductance is removed in the other.

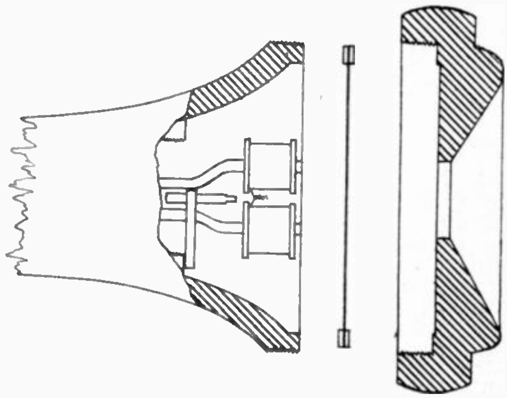
A machine belting of paper is manufactured in England, which is said to be very strong and durable. The paper is specially prepared and compressed and cut into links, which are punctured at the ends and fastened together by a wire rod and protected on the margin by single heavy leather links. The belting will not stretch and where tried is reported to give perfect satisfaction. It is said not to be affected by climatic changes and conditions.—*Scientific American Supplement.*

WIRELESS RECEIVER DIAPHRAGM

A telephone receiver with a bad diaphragm is much less sensitive than one with a good diaphragm.

For wireless a very thin diaphragm is the best. If the diaphragm can be adjusted, that is, the distance between the poles of the magnet and it can be changed, it is much better than when only possible to place it at one distance.

To make the diaphragm of an ordinary receiver adjustable unsolder the small wires of the coils from the leading in wires and then remove the peg *A*. Now unscrew the coils and magnet till the ends of the poles are just flush with the edge of the hard rubber case. A pole will now have to be drilled into the case so that the pin *A* may be driven back in as it was before. Resolder the wires and that part of the job is done.



Take a very thin diaphragm and attach a ring of soft rubber to each side of it. These rings should be ⅛ in. wide and about 1-32 in. thick. Fasten the rings on by means of rubber cement or tire cement.

Another way to do this is to take an old inner tube of an old bicycle tire and cut a ring from this. In the latter case the rings should be ¼ in. high and in the shape of a cylinder. This is slipped over the edge of the diaphragm, which should be a trifle smaller than regular, after which glue as before.

To keep the magnet from holding the diaphragm, if they should come in contact with each other, give the magnet ends a few coats of good shellac.

After the glue or cement has dried the receiver is ready to assemble. It may be found necessary to let the diaphragm dry while clamped between two boards.

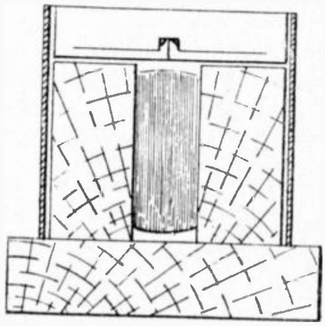
It will be impossible to raise the coils of some head band receivers on account of the way they are built, so that in such cases it is doubtful whether it would be advantageous to make the adjustment in any other way, such as turning off a small amount of the end of the screw.

WINSLOW A. KINGMAN.

A HOME-MADE GALVANOMETER

A galvanometer such as the one described below will prove useful to the experimenter in many ways, and is simple enough to be constructed by any amateur.

The materials required are a small compass, a cylindrical block of wood of the same diameter, a piece of brass tubing which will slip



rather closely over the wood cylinder, some No. 24 magnet wire, two binding posts and a suitable block of wood or hard rubber for the base.

The compass should be procured first, as upon it will depend the dimensions of the other parts. The magnet wire may be obtained from an old electric bell, if desired. The No. 24 wire is named as being a convenient size for ordinary use, but the block may of course be wound with wire of almost any size.

Taking the cylindrical piece of wood,—which may be a curtain rod if the compass is small enough,—saw off a piece of about the same length as the diameter of the rod. Into this cut a slot from ¼ to ½ in. wide, depending upon the size of the block, and the same depth, across the top and bottom and down the sides. Into this slot wind as much of the wire as can be gotten on, leaving the two ends of the wire long enough for connecting to the binding posts. Now mount the block on the base, upon which the two binding posts have been fastened, and connect the wires to them.

Next set the compass on top of the block and cut a piece of the brass tubing long enough to reach from the base to the top of the compass. Drill a hole in the tubing and fasten it with a screw into the wood block. Now turn the compass until the north and south line on the scale is parallel with the slot in the top of the block. Wedge or otherwise fasten the compass in this position and the galvanometer is complete.

This type of instrument is of course not so sensitive as though the compass was in the centre of the coil instead of above it, but is more convenient to use, and will stand rough handling.

J. CARLTON PAULMIER.

EDITORIAL

We are now settled in our new offices at 221 Columbus Ave., where we shall, as usual, be glad to welcome all those interested in our magazine, whether subscribers or not.

Our readers have, we trust, detected an improvement from month to month in the quality of the articles published in *Electrician and Mechanic*. We shall continue to improve the magazine, and in order to do so, we solicit helpful and practical manuscripts, from which we may make selections for publication. We invite you to submit such articles for our consideration. By studying recent issues of *Electrician and Mechanic* it is easy to see the kind of articles which we use. All manuscripts should be written on one side of the paper only, and all drawings must be neatly done in india ink. The general tendency in making drawings is to make them too large, and lines are made too fine. Drawings should seldom be made more than twice the size at which they are to be reproduced, and must be made with thick, black lines. Manuscripts should in all cases be accompanied by return postage.

The subject of aeronautics is mentioned on all sides, and we shall therefore publish from time to time articles on this interesting subject. As usual these articles will be practical, and intended for the use of amateur aeronauts who intend to build or already have built their own machines. We might add that we have on hand a list of excellent books on the subject of flying, which we will be pleased to mail to those of our readers who desire it. These books describe the construction of gliders, biplanes and monoplanes, and contain all the necessary theory of flying.

Mr. James M. Murdock writes this month on a timely subject, and brings out a point which is overlooked by 99 per cent. of the experimenters in wireless telegraphy. In all this discussion over the "Amateur" question, with the possibility of restricting "amateurs" to certain wave lengths, the fact that interference depends to a great extent upon the degree to which a wave is damped has not been taken into account. The production of undamped waves would, in most cases, entirely eliminate interference and we suggest that those of our readers who are interested bend their efforts in this direction.

Owing to illness, Mr. P. LeRoy Flansburg was unable to continue his series of articles on "Machine Shop Practice," in this issue. It will be resumed in the September issue.

We can promise our readers some excellent articles in the next number of the *Electrician and Mechanic*. A few of the titles are as follows: "The Manufacture of the Incandescent Lamp," by W. E. Albertson; "Machine Shop Practice—Part III—The Shaper," by P. LeRoy Flansburg; "Electrical Shop Notes," by H. Winfield Secor and "Electromagnetic Wave Phenomena," by Samuel F. Kerr. Mr. Perrigo will continue his department, "Machine Shop."

Mr. Edward H. Guilford has joined our editorial staff and will work on the electrical side of the magazine, as well as the Wireless Department. Mr. Guilford has been responsible for the Wireless Department since the first of the year, and no doubt will be as successful in his enlarged field as in his previous work.

With our present much more spacious offices we will be able to give lectures on Wireless Telegraphy, demonstrations of instruments, etc., during the coming winter. Our completed plans in this direction will be announced in a later issue.

Have any of our readers about Boston noticed that the signals from the New York wireless stations have a tendency to die away every few minutes? Who can explain this peculiar phenomenon?

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.

1412. **Wiring Diagram.** C. F. V., Brooklyn, N.Y., asks: (1) How to connect up the following receiving instrument? (2) What is the receiving distance of my instrument? Aerial 65 ft. high, 40 ft. long, wires 18 in. apart composed of No. 18 bare copper wire; double slide ball-bearing tuning coil; fixed condenser, mineral detector, two 75 ohm watch case receivers. Ans.—(1) See Mr. Guilford's wiring diagrams in May issue. (2) See answer to question No. 1311.

1413. **Station Improved.** K. L., Kansas City, Mo., asks: (1) About what would my receiving range be? Have read Mr. Getz's article, but do not quite understand it. (2) What instruments would improve this outfit? (3) Please explain how to make a simple variable condenser to use with above outfit. Ans.—(1) Your aerial is entirely too short, make it 100 ft. long. (2) Your instruments are all right as they are. Try a perikon detector. (3) Use two sheets of tinfoil 12 in. x 15 in. pasted upon cardboard with paper dielectric and vary capacity by sliding one sheet of tinfoil over the other.

1414. **Helix. Ten Mile Coil. Sending Condenser.** W. P. T., Springfield, Mo., asks: (1) In constructing a sending helix for a 6 in. spark coil, which is the best to use: brass ribbon ½ in. wide, or brass or aluminum wire, size No. 8? Please give height, diameter distance between turns, and number of feet of wire or ribbon, for the above helix. (2) What size coil and what height and length aerial would be required for intercommunication between two places ten miles apart, using suitable receiving instruments and suitable sending inductance. One of the above places is situated in the city, and the other is a farm with lots of timber on it. (3) Which is the best for a sending condenser, a glass plate variable condenser or Leyden jars? What capacity should a condenser for the above coil have? Ans.—(1) Use 60 ft. brass ribbon wound on form 2 ft. in diameter, space edges of each turn, ½ in. apart. (2) A coil with a 15 in. core and 6 to 7 lbs. of No. 30 wire on secondary would serve your purpose and would maintain communication under all conditions. Use an antenna at least 70 ft. high. (3) Either would do, and the capacity can be determined only by trial.

1415. **Sending Distance.** H. A. B., Watertown, Mass., asks: How far could I receive with an aerial 95 ft. high of 6 wires 2 ft. apart and 150 ft. long. A doughnut transformer of 1,500 meters, a variable condenser, a fixed condenser, and a perikon detector, and two 1,000 ohm receivers? (2) Will you also tell me how many meters will 10 turns of No. 28 enamel wire give wound on cardboard 5 in. in diameter and how many meters will 10 turns on No. 24 enamel wire give wound on cardboard 4 in. in diameter? Ans.—(1) See answer to question No. 1311. (2) We do not understand your question. Write again more explicitly.

1416. **Condenser.** F. S. W., Hyannis, Mass., asks: (1) What size wire are the potentiometers wound with and how long are they and how big round and how long is the tuning coil to be and how big round and what size wire are they to be wound with? (2) What kind of a condenser is used and how do you make one? Do you connect all the paper together and all the tinfoil together and how much paper and tinfoil do you use or how do you make it? (3) What distance can you receive with this detector? I am enclosing you a piece of wire. What size is it and can it be used for wireless work? Ans.—(1) See February issue of this magazine, which describes a complete receiving station. (2) A condenser is described in the March issue. Build your receiving condenser after this pattern, but use paper dielectric instead of glass. 5 or 6 sheets of tinfoil 5 x 8 will be sufficient. (3) A peroxide of lead detector is about as sensitive as carborundum. The enclosed wire is No. 22 iron wire.

1417. **Telephone Receiver.** C. T. R., Santa Cruz, Cal., asks: (1) Have you published or would you publish an article giving drawings and description of a good telephone receiver for wireless? (2) Other conditions remaining the same, how does the receiving distance increase with increase of receiver resistance above 1,000 ohms? (3) Is the winding of coils with enameled wire for the above receiver beyond the reasonable hope of a careful amateur with a good screw cutting lathe? Ans.—(1) An article on that subject will be published shortly. (2) The increasing in receiving distance increases very little with an increase of resistance above 1,000 ohms. (3) No; receivers may be very easily rewound, ordinary patience and care is all that is needed.

1418. **Loud Speaking Telephone used for Wireless Telegraphy.** H. L., Dorchester, Mass., asks: Is the loud-speaking telephone described in the May issue of *Electrician and Mechanic* suitable for wireless telegraphy if wound for 1,000 ohms resistance in circuit with potentiometer and batteries? Ans. Yes, the telephone can be used satisfactorily on a wireless telegraph receiving outfit.

1419. **Spark Coil.** E. L. S., Lexington, Mass., asks: How much wire would I have to put on a secondary of a spark coil if the tubing is 7½ in. long and 1½ in. in diameter? How large a diameter would it have when wound or finished? Ans.—Your data is insufficient. Write more fully.

1420. **Spark Coil.** H. N., Worcester, Mass., asks: I have an induction coil 10 in. long with two layers of No. 16 double cotton covered, copper wire on the primary and five lbs. of No. 36 single cotton covered wire on the secondary. The best spark that I can get using six dry cells is only from ½ in. to ¾ in. long. How large a spark should it give and how much current should be used on the primary. Ans.—You should get a spark about 4½ to 5 in. long by using a larger primary current at a voltage of about 15. Do not use dry cells if you wish to obtain maximum length of spark.

1421. **Telephone Receivers.** J. D. D., Liberty, N.Y., asks: (1) How can I get the poles out of the case and what size wire shall I use? (2) Can I make a toy motor from a telephone generator and how? Ans.—(1) Two screws will be found at the back of the case which hold the poles in place. Unscrew them and the poles and magnets will come out easily. (2). No.

1422. **Loose Coupler.** E. D., Franklin, N.H., asks: (1) Will it impair the efficiency of a loose coupler to wind the outside wire primary on a tin cylinder if it is covered with paper? (2) Can an induction coil be made to work on 110 volts a.c. as a transformer open core, by connecting suitable resistance in the primary. (3) Is the doughnut transformer as efficient as the loose coupler? Ans.—(1) Not if the secondary wire is thoroughly insulated from the tin. (2) Yes, a large condenser should be bridged across the secondary. (3) Yes, when used in connection with suitable condensers.

1423. **Hydrogen Gas.** P. S., New Haven, Conn., asks: (1) How to produce hydrogen gas, and the best way to force it into Geissler tubes. (2) Is there any book which gives rules for producing different gases such as hydrogen, nitrogen, oxygen and carbonic acid gas. (3) Is there any gas needed in Crooke's tubes. Ans.—(1) Hydrogen gas is produced by the action of dilute acids on many metals. The easiest way to produce it in small quantities for laboratory use is by dissolving metallic zinc in dilute sulphuric or hydrochloric acid. On a large scale it is usually produced by treating iron filings with sulphuric acid. The only way to force it into Geissler tubes is to exhaust the air with a pump, and then allow the hydrogen gas to fill the vacuum produced. By pumping out two or three times and refilling, the last traces of air disappear. (2) Any elementary chemistry would tell you how to produce various gases. Hydrogen we have given the method for. Nitrogen is produced by burning phosphorus in a closed vessel of air, and washing out the phosphoric anhydride smoke by allowing it to stand over water. This gives atmospheric nitrogen, which, of course, contains small quantities of argon. Oxygen is usually produced on a commercial scale of heating in a copper or iron retort a mixture of potassium chlorate and black oxide of manganese. It may also be produced by the action of water on sodium peroxide, which is now obtainable at not very high price. Carbonic acid gas is produced by the action of hydrochloric acid on marble dust or chips. (3) Crooke's tubes are as free from gas as is possible to make them, being exhausted with an air pump of the highest possible efficiency.

1424. **Storage Battery.** F. P. T., Tyler, Texas, has a large number of 6 x 8 in. glass jars, such as are used for gravity batteries. He asks for directions for making storage cells suitable for being contained in these vessels. Ans.—Round jars can be used, but of course they require more solution than would be needed did the plates fill the space more economically. Several appropriate articles have appeared in the columns of this magazine, at various times, and you will find their reading to be profitable. These are: "How to Make a Storage Battery," in the May and June, 1907, numbers, and the two articles in the "Engineering Series," in the April and May, 1908, numbers. Also, there is the complete book on the subject by A. E. Watson, advertised in this magazine.

1425. **Magneto Generator.** F. L. G., Howell, Mich., asks: (1) What is likely to be the fault with the direct current generator he has made from a telephone magneto, as described in the *Electrician and Mechanic*, in the March, 1907, issue? He has tried several sizes of wire for winding the armature, between Nos. 23 and 28, and while with alternating current connections the output is vigorous, the direct connections give only about 3 to 4 volts. (2) What are the sizes of certain samples of wire sent? Ans.—(1) It is rather indeterminate how many volts you obtained when using alternating current connections; you can feel the alternating effect with about half the voltage that you can with direct. Possibly you do not have the brushes set in just the right line for best commutation. When the armature core rests in the position to which it is pulled by the permanent magnets, the contact points of the brushes should rest on about the centre of the semicircular commutator segments. (2) Nos. 22, 26, 33, and 36.

1426. **Alternator.** J. M. P., Valley Falls, Kan., writes regarding an old-style Thomson-Houston 10-pole, smooth armature-core alternating current dynamo which he sometimes runs in connection with a "Royal" induction dynamo. The latter readily gives 1,100 volts, but the former only 110. He describes the winding, it being of rectangular wire, and asks for directions for rewinding for the full voltage. Ans.—We are very familiar with this machine, having had a hand in its original design. It is the one of which a cut was given on page 35, in the August, 1907, magazine. We are at loss, however, to understand some of the statements you make regarding the winding, for we are not aware that one was ever wound at the Lynn factory for less than 1,100 volts. The ten "pan-cake" coils were connected in series. It is possible that some one, at a more recent date, changed the connections so that the coils are now in parallel, therefore reducing the voltage to the figure you mention. A few machines of earlier design were actually wound for 300 volts, to operate Prof. Thomson's "compensator" system. Round wire was used for such armatures by the Westinghouse Co.; but in the case of this machine, you will not get in the required number of turns, unless you employ the rectangular shape. The coils should be wound on a central form between two concentric side pieces. Metal clips can be used to hold the coils while they are being taken from the form and transferred to the armature core. Thin taping can be used, in addition, if desired. Wind all ten coils just alike, and place them in exactly similar order on the core. Use insulation that is reinforced by thin mica. Lead the ends of the coils down through the flanges that encircle the armature head, in the wooden bushings provided for the purpose, and then in the grooves in the wooden ring embed the joints as fast as they are made. Start with any two coils and connect their inner ends together. Then at the adjacent position join two outer ends, then two inner ones, and so on, until finally two outer ends are left. Lead one of these, insulated with best rubber, out through the hole in the shaft, to one of the commutator segments, the other to a collector ring. A similarly insulated wire will lead from other segment of commutator to the other collector ring. Thin strips of best mica must be placed over the armature core, practically covering it, and binding bands wound in a sufficient number of places to cover about one half the coils. Let each band be not over ½ in. wide, else too much heating from eddy currents will result. We would be glad to receive additional information regarding this machine, for it is not clear how you run a 110-volt machine in connection with one for 1,100 volts, and you make no reference to use of transformers. It would appear, however, that you run the machine electrically connected to the secondary mains, while the other is feeding into the primary. You are therefore operating the machines in parallel,—a very ticklish operation with those old high frequency generators. Of course you must have the frequencies exactly the same and the critical instant for connecting the two determined by means of a "synchronizer." If you have no such device, it is not strange that one machine gets hot,—the wonder is that you did not burn it out in the first half hour's run.

1427. **Transformer.** H. L., Buffalo, N.Y., has a transformer core, of which he sends a sketch, and asks what the winding should be to allow use on a 110-volt, 25-cycle circuit and give a secondary output of 390 volts and 3½ amperes? Ans.—Your sketch is not clear, but we imagine the dimensions to be that a sheet is 4⅜ in. x 7 in. outside, 1 in. wide, and the stack of them is 2 in. high. Since you desire about 3½ times as many volts from the secondary as you put into the primary, you will need, in addition to the magnetizing current, 3½ times as many amperes, or about 15 amperes input for 3½ amperes output. Primary should then have about 220 turns of No. 10 wire, and secondary about 780 turns of No. 15 wire. You will be unable to find space for so much. The reason is, that you would be trying to get over a kilowatt of energy transformed in a device conveniently capable for only about half as much. You may, perhaps find recourse in making what is known as an "auto-transformer." In this, primary and secondary are connected, one being merely a continuation of the other, though with a change in the size of the wire. Wind 110 turns of No. 10 wire on each leg of the core, these two being properly in series. Try it on the 110-volt circuit; only a small current should flow. If you get the two connected in the wrong way, you will instantly blow the fuse. Now, if you can get on 560 turns more, of No. 15 wire, as a continuation of the coarser, you will get the desired results; for the ends of the coarse wire are to be connected to the 110-volt supply, while one of these terminals and the extreme end of the finer wire will be led to the 390-volt apparatus, having in its circuit a total of 780 turns.

1428. **Electromagnetic Induction.** P. H., Bentonville, Ark., (1) states that he has been taught that an electromotive force was induced whenever conductors cut through a field of magnetic force, but some encyclopædias state that the phenomenon occurs only when the number of lines of force that embrace a coil is changing. Which is right? (2) An Emerson 50-watt, 60-cycle induction fan motor was used without its fan for driving a small generator, but the motor burned out. What was the reason? Ans.—(1) Discussion over this difference of definition was rampant 30 years ago, and was supposed to have been pretty well argued out. However, only a little over a year ago, the discussion broke out afresh. When we consider that the whole conception of lines of force is merely an invention, that they really have no existence, it is not strange that difficulties are experienced in explaining all phenomena by their aid. The most accepted evasion of the difficulty is in admitting that really the statements are really two different ways of saying the same thing. Let the actual "cutting" be adhered to for sake of a premise. Then, as in case of a transformer, where apparently there is no cutting, but merely a change in the number of lines of force, let the invention be carried still further. If by an increase of the primary current, an increase in the number of lines took place, where did they come from, and when the number reduced, where did they go? The answer is that the lines of force,—acting in a complete circuit, and floating around in space like smoke rings,—are called in by action of the current, and link themselves with the coil. Now to get into that position, every line or ring of force had to cut across every turn of the coil, and therefore induced in it an electromotive force. Likewise, when the current lessened or stopped, the lines of force were released and sailed off again into space, again cutting across the conductors. (2) A fan motor is really a hot-box. Instead of cooling a room, it may actually heat it. The current of air or circulation is supposed to keep not only the person cool, but to cool the motor too. If now, you remove the fan, the circulation is stopped, and the heat remains in the motor, and soon the temperature of the coils is dangerously high. You should have a small "power" motor, which look like those for driving fans, but are wound with more turns of wire.

1429. **Cast Iron.** I. H. S., Siegfried, Pa., asks: (1) Is cast iron suitable for the field magnet of a small dynamo, and will it answer as "gray" iron for the rotary converter recently described? (2) Where can sheet brass be obtained? Ans.—(1) Cast iron is in two quite different grades; one that is very liquid when melted, and appears whitish when cold: it is used for making thin casings, as for stoves. The other grade will not run into the small portions of the molds so well; appears gray when cold. This is a much softer grade and is much more easily machined than the other, and besides it has a higher magnetic permeability. The summation of the directions is that when getting castings for a dynamo, do not go to a stove foundry with your patterns, but take them to one that makes a specialty of machine castings. For a retail dealer that makes a specialty of small trade, address Wightman & Co., 130 State St., Boston. We could give various addresses of manufacturers or wholesale dealers.

1430. **Converter Castings.** W. H. C., Round Lake, N.Y., asks: where he can get castings of the rotary converter recently described? Ans.—We do not know; but if any one of our friends makes the patterns, and has castings for sale, we should be glad if he will so inform us.

1431. **Engine Trouble.** L. C. C., New Orleans, La., has a Pope Tribune, 1904 model automobile, but dislikes the vibration the single-cylinder 4-cycle engine produces. He has also a 2 h.p. 2-cycle engine, and asks if it can be added to the turnout with any advantage? Ans.—We have a suspicion that the scheme is impracticable. The framework may not be adapted for carrying the additional weight, and difficulties of control may present themselves. We advise you to correspond with some specific automobile publication.

1432. **Choke Coil.** E. F. Z., Buffalo, N.Y., asks for directions for making a coil, giving size of wire, number of turns, form of core, etc., suitable for operation on a 110-volt circuit, and give, without resistances, from 10 to 30 amperes. Ans.—Your data is insufficient, for you do not state the frequency, and we know that both 25 and 60 cycle circuits are standard in your city, and you do not give any idea as to the variation of e.m.f. desired. You probably do not mean to be able to operate the coil on a short circuit, and that then the 30 amperes will flow. We can design a coil that will comply with such specifications; but we presume that you intend to have some appreciable resistance in circuit, say an arc lamp. If you will state what voltage you desire and the frequency of the circuit, we will be able to advise you fully as to the design.

1433. **Inductance of Tuning Coil—Inductance of Helix.** S. B. B., New London, Conn., asks: (1) What would be the wave length of a tuning coil single slide with 295 turns of No. 18 d.c.c. wire on a core 2½ in. in diameter? (2) How can you tell what the different wave lengths of your helix are? (3) How would it be to my advantage to make the above tuning coil double slide? Ans.—(1) It has enough inductance when used with aerial and condensers of ordinary type to receive waves up to 1,600 meters in length. (2) See Mr. Getz's article on the calculation of wave lengths in the Dec., 1908, issue of this magazine. (3) A longer receiving range is made possible by using a double slide tuning coil.

1434. **Aerials.** G. C. R., Middletown, Md., asks: (1) How far can I receive with the following instruments? My aerial is made of 4 strands of No. 26 B. & S. gauge, bare copper wire elevated at the highest end to 30 ft., and having a length of 50 ft. I have a single slide tuning coil, which is about 6 in. in diameter, and which is about 15 in. long, containing about 175 ft. of wire. My detector is like the one described in the June, 1909, issue of the *Electrician and Mechanic*. I have a pair of 1,000 ohm receivers. (2) How can I increase my receiving radius? (3) Is it dangerous to have an aerial near a building on account of lightning? (4) Is a horizontal aerial better or not as good as a vertical aerial? Ans.—(1) See answer to question No. 1311, May, 1910. (2) Use a perikon detector double slide tuning coil potentiometer. Your aerial is too small. See May, 1910, issue for aerials. Yes, Mr. Guilford's articles explain the proper protection of aerials from lightning. See the May, 1910, issue.

1435. **Receiving Distance.** W. F. H., Boston, Mass., asks: Will you please estimate my receiving distance with the following equipment? Doughnut transformer, perikon detector, fixed condenser, variable condenser, and pair Murdock Pro. 2,000 ohm phones. Aerial as per sketch enclosed and 80 ohm potentiometer, 4 wires connected together at the bottom and ending dead at the top. Instruments located 15 ft. above ground or about 40 ft. below the aerial. Ans.—See answer to question No. 1311, May, 1910, issue.

1436. **Umbrella Aerial.** S. H., Dorchester Centre, Mass., asks: (1) What would be the best way to construct an aerial on my roof, which is 80 ft. high? (2) Would my method be practicable as per my sketch? All wires on T's are 1½ ft. distant. Ans.—(1) Connect all aerials at the top and also at the bottom, making an umbrella type aerial. Run leading in wire from bottom of aerial to instruments. (2) This method is practicable.

1437. **Brant Rock System.** C. M. K., Ipswich, Mass., asks: (1) Where may I purchase iron .015 in. in thickness as used in Mr. Getz's transformer in the June, 1909, issue? (2) Can you explain the system Brant Rock uses in transmitting? Please give diagram. (3) Please give diagram of the best aerial in your opinion. Ans.—(1) Wilkinson's Hardware Store, Washington St., Boston, Mass., can supply you with sheet iron. (2) The Fessenden system employed at the Brant Rock Station is a secretive system. A continuous spark is used, and ordinarily a train of waves, about 1,500 meters in length, is sent out. When a signal is to be made, a telegraph key is pressed, short circuiting a few turns of the helix or oscillation transformer. This makes the dot or dash sent out of a shorter wave length than the rest of the waves. To receive this message a complicated set of receiving instruments is used, which are capable of turning out waves longer than ½ of 1% of the wave wanted. For diagrams see Fleming's handbook of Wireless Telegraphy, 1908, edition. (3) The "best" aerial is determined solely by local conditions. See the May, 1910, issue of this magazine.

1438. **Improvement of Set.** J. F. A. D., Marblehead, Mass., asks: (1) In what way could I improve following set? One double slide tuner, 7 in. long, 2 in. diameter, fixed condenser, silicon detector and one 80 ohm receiver. (2) Give diagram of same. Ans.—(1) Add a variable condenser and a perikon detector, with potentiometer. (2) See May, 1910, issue for diagrams.

1439. **Function of Condenser.** F. C. N., Windsor, Conn., asks: (1) Could a condenser be employed to strengthen the current of an ordinary medical machine? That is to increase the e.m.f. of the secondary. (2) If so, about what size would be practical? Ans.—(1) No.; the electromotive force would be decreased with its use.

1440. **1,000 Mile Wireless Stations.** H. W. S., Amityville, L.I., asks: I would like to know the complete construction of a tuning coil, double slide, that when in connection with a silicon and electrolytic detector and 1,000 ohms resistance receivers will receive from 500 to 1,000 miles. The antennæ is 60 ft. high at one end and 38 ft. at the other, being made of 4 strands of No. 12 cu. wire. Would a potentiometer be necessary in the circuit; if so, how is it best made? Please give diagrams of complete circuit. An answer will be greatly appreciated. Ans.—Your questions are all answered in the series of four articles, by E. H. Guilford, "A 1,000 Mile Wireless Station," which began in the February, 1910, issue.

1441. **Anchor Gap—Iron Tower for Aerial.** C. E. W., Buffalo, N.Y., asks: (1) Explain the use of anchor gap and where is it attached? (2) Will an iron pipe tower 100 ft. high and wooden pole on tower 50 ft. high cause loss of energy? Ans.—(1) An anchor gap is used on a looped aerial so that in transmitting the antenna may be used as a plain, straight aerial. (2) Yes, a small amount of energy would be lost, but not enough to cause any great trouble.

1442. **Specific Inductive Capacity.** R. B. T., Jamestown, N.Y., asks: (1) What is the specific inductive capacity of plate glass? (2) How many sheets of tin foil each 2½ in. by 3½ in. are necessary for a condenser that is shunted across the contact points of a key, when 110 volts are used? (3) I do not understand the term kilowatt when applied to transformers. Does it mean that in a 1 k.w. transformer, each volt used in the primary is raised to 1,000 volts in the secondary? Ans. —(1) The specific inductive capacity of glass varies from 5 to 8 as compared with air. Seven would probably be a fair number to take for plate glass. (2) It would depend upon whether the current was alternating or direct. If it were alternating a very small capacity shunted across the key would suffice to wipe the spark away. For alternating current try 10 or 12 sheets. If less than ½ k.w. is being used, no condenser is necessary. If the current is direct, a condenser made of 15 sheets of tinfoil 4 x 6 with paraffined paper as a dielectric will suffice. (2) The term "kilowatt" is used to state the magnitude of electrical work. It is equal to a 1,000 watts, the watt being the product of 1 volt x 1 ampere. If a transformer is rated as ½ k.w. it means that the number of amperes flowing through the transformer multiplied by the voltage at which the current is applied is equal to ½ k.w. or 500 watts.

1443. **Potentiometer.** E. S., Providence, R.I., asks: (1) How to make such a piece of apparatus? (2) Is there a government directory of wireless telegraph stations? (3) Where can enameled wire, or wire covered with cellulose acetate be obtained. Ans.—(1) See "Construction of a 1,000 Mile Wireless Station," in the February issue. (2) Yes, such a book is periodically issued, but the last one is already out of print. (3) Address D. & W. Fuse Co., in your city.

1444. **Machine Shops for Apprentices.** G. L. A., North Wilkesboro, N.C., asks for the address of machine shops who take boys and train them, as referred to in Mr. Perrigo's article on "The Modern Apprentice," in the June, 1910, issue. Ans.—All the shops of the Sante Fe Railroad system, from Chicago west to San Francisco, and from Deven in the north to Clebourne, Texas, in the south. Address: Superintendent of Apprentices, Topeka, Kan. The shops of the New York Cental Lines. Address: Superintendent of Apprentices, Grand Central Station, New York City. The shops of the General Electric Company. Address: Superintendent of Apprentices, Lynn, Mass. There are also a number of smaller concerns which take apprentices on similar terms.

1445. **100 Mile Station.** T. E. M., Madison, Me., asks: (1) What instruments are needed for a 100 mile receiving set, with the aerial I have given? (2) What size wire and how much should the instruments be wound with? (3) How much do you think the set should cost me, if I build it myself and have success? Ans.—(1) and (2) See articles by E. H. Guilford on "1,000 Mile Wireless Station," which began in February issue. The same instruments would be used for your receiving station. (3) From $5 to $10.

TRADE NOTES

Henry Disston & Sons are making improvements to their great establishment, the Keystone Saw, Tool, Steel and File Works, in Philadelphia, which will represent an additional investment of about $500,000.

This includes the building operations completed in the last fourteen months, which takes in the erection of a storage warehouse, a pattern storage building, a blacksmith shop and a new machine shop with up-to-date equipment.

Foundations are now being laid for a two-story structure, 180 x 43 ft., which will be another addition to the extensive file-making department. The building will be equipped, of course, with all modern operating machinery, all of which has been designed and built by the Disston organization.

In a few days work will be started on a two-story building, 290 x 63½ ft., with an L, 181 x 69½ ft., to accommodate the machine knife and jobbing departments, wherein are made the various kinds of machine knives, such as woodworking knives; chipper, bed and hog knives; paper trimming, leather-splitting knives; shear blades, etc., while in the jobbing department are turned out steel plates for cutting and creasing machines; cylinder presses; pattern plates; lawn mower, circular cloth, candy, paper knives, etc.; multiple clutch discs and flat steel springs of all descriptions.

Incidentally, a large amount of new machinery, perfected by Disston experts, is being installed in all departments of the establishment.

At an early date work will be started on a new and enlarged two-story fireproof building for the cold rolling department.

The Disston management reports that business has never been as heavy in the history of the organization as it is at present. The volume of repeat orders is very large.

"It is a business axiom," said an official of the company, "that repeat orders are the strongest evidence of solid, substantial merit. We are receiving them in constantly increasing volume, thus necessitating these further extensions of the plant in general.

"The new buildings have been specially designed with a view to obtaining the maximum amount of light and the best possible ventilation. No expense or pains are spared to provide every convenience for the workmen, and such a policy has done much toward producing the high quality that characterizes the Disston products."

It is a notable fact that all buildings in the big plant recently erected by Henry Disston & Sons, in Toronto, Canada, are model structures in respect to light and ventilation. The old works there having been outgrown in the three years of its existence the new buildings, in a more desirable location with better transportation service, were planned looking to increased and better facilities for the manufacturing of Mill Goods, such as circular band, gang and cross-cut saws, etc. A large amount of extra ground is being held in reserve for future extensions.

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This firm has almost a full century of experience back of it, and is today one of the world's largest makers of guaranteed hand tools for mechanics. In addition to their four large lines of tools for electricians, machinists, carpenters and tinsmiths, they are also well known as the oldest established manufacturers of tinsmiths' machines.

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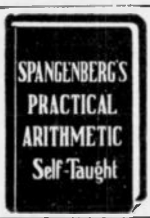

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