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## ELECTRIC LIGHTING IN PRIVATE INSTALLATIONS

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The problem of electric lighting as regards ease and convenience has been satisfactorily solved in cases where a central station service is available, as all that is required is the turning on of a switch. In country houses and private installations of a similar description, however, unexpected difficulties have been encountered, owing to the necessity of the provision of what is virtually a small power house. This involves attendance, and a choice has frequently to be made between the employment of a technical man with a technical man's wages, and the exciting and expensive recreation of trusting the plant to a

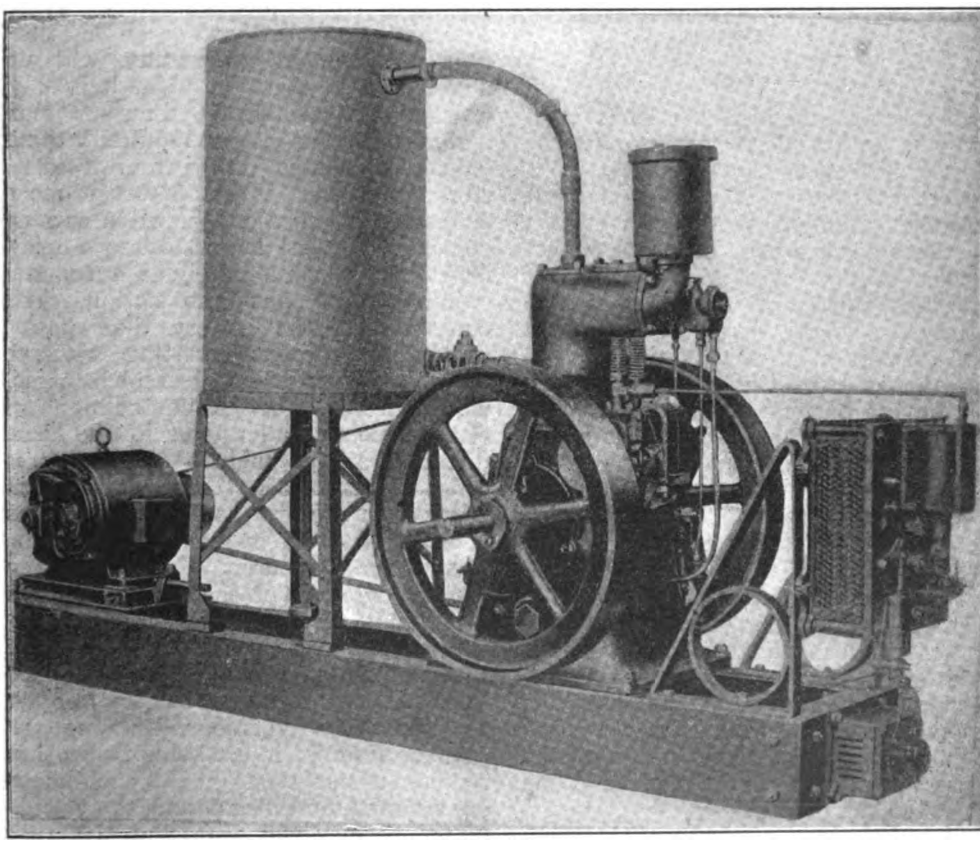


Fig. 1
General Appearance of Plant

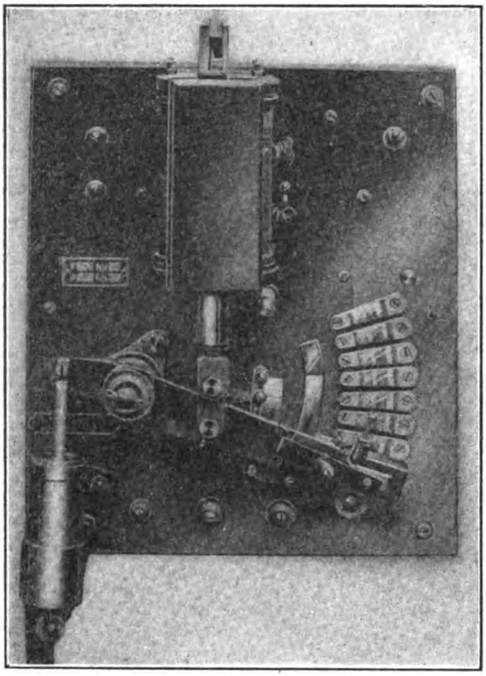


Fig. 2
The Controller

gardener-engineer odd-jobber, whose chief virtue is an unfailing optimism in the midst of distressing circumstances.

Moreover, even with a good equipment of producer and gas engine, or oil engine, the times occur when the prime mover is being overhauled or has the spirit of cussedness in it, and a standby storage battery of sufficient capacity to carry a good proportion of the lighting load is then appreciated. One cannot (or should not) have a battery installation without paying for it, and apart from the initial cost, there is the fact that unless the battery is treated with due care it is apt to develop complaints the cure of which is beyond the tender mercies of the gardener aforesaid.

It is therefore interesting to note a recently devised automatic generating set which is calculated to be always on hand when required to do work. No attendant is required to start and stop it; beyond the technical knowledge required to fill the tank, and to clean and oil the engine, the man in charge may be of the usual standard of intelligence, and Messrs. R. A. Lister & Co., Ltd., of Dursley, England, appear in their Bruston system to have put their finger on a serious fault in private lighting plants and to have found the remedy.

The general appearance of the plant is seen in Fig. 1. The plant is self-contained and is delivered ready to work, no special foundation being required, but the plant must be set level, and it is advisable to set a soft pad (lead or felt) at each corner for the bed plate to rest upon, in order to ensure smooth running. The circulating water tank must also be protected in frosty weather. In the case of large installations the plant may be divided into two or three different units. For instance, in the case of a 400-light installation, two units can be provided, *viz.*, one each of 100-lights and 300 lights, or, if preferred, two each of 200 lights. These units are connected up in such a manner that a light load would start up one set (the smallest), but upon the load being increased the second set would automatically switch itself in. Any number of separate units can be controlled in this manner. It is, therefore, possible to work an installation of any size practically without attention. To start the plant it is only necessary to switch on three or four lamps or more as may be required; these lamps are lighted direct from a small storage battery. When, however, more lamps are switched on, the extra current demanded by the lamps causes a relay instrument, which is simply an automatic switch, to be put into action. The current from the battery then passes through the automatic starting switch or controller and is delivered to the dynamo, which then acts for the time being as an electric motor, and rotates in the same direction as the engine, to which it is connected by belt. The engine then revolves in exactly the same manner as if it were started by hand. The engine then commences firing, and, overcoming the motor effect of the dynamo, starts generating electricity itself, delivering the direct current to the lamps, and at the same time replacing the energy which has been taken from the battery in order to start the dynamo. Assuming the number of lamps in use being below that required to start the plant and such lamps are required for a long period, the voltage of the battery will drop; but this very fact is provided for in the system, and such a drop of voltage will also actuate the relay and cause the plant to start up and recharge the battery. When the lamps are switched off and the battery has been charged up to the standard voltage, the plant automatically stops. The engine may be driven either by gas or petrol, and the automatic arrangement, depending as it does solely on turning the lights required on or off, is remarkable. The system saves waste, as practically the whole of the current is delivered direct from the dynamo instead of being first used to charge up the accumulators and subsequently to discharge them, the loss in this operation being at least 40 percent of the power generated; and it also ensures long life to the battery, as the latter is always kept charged, and never falls below the standard voltage; it is automatically charged up, although no lamps may be switched on. The principal feature of the arrangement is its simplicity and absence of complicated mechanism, as will be seen from a brief specification of its components. The engine is a low-speed petrol or gas engine of standard design, the only addition being a simple valve lift to relieve compression for starting and stopping. The dynamo is a standard pattern shunt-wound machine coupled to the engine by means of a leather belt. The controller is similar in design to the standard type solenoid starting switch, many of which have been used for years, and a form of which is shown in Fig. 2. The switchboard consists of an enameled slate and contains an ammeter indicating the current being used; an ammeter indicating the current being generated; a voltmeter indicating the pressure; a "Lister" patent relay which controls the starting and stopping of the plant, a safety circuit breaker for protecting the battery and dynamo; a safety fuse for protecting the wiring; and a voltmeter switch. The switchboard cabinet, shown in Fig. 3, is designed for supporting both the switchboard and the battery. It measures 3 ft. 7½ in. high, 2 ft. 6½ in. across the front, and 1 ft. 11½ in. from back to front. The compactness of the battery is therefore apparent.

It will be seen that the plant is less likely to fail than the ordinary hand-operated plants. The cost of erection is practically nil, the plant being self-contained and as sent out ready for use. No special foundations are required, and as the set is not fixed to the floor it can easily be moved from place to place. It only occupies a floor space of approximately 9 x 4 ft., and, owing to the efficient and automatic arrangement for oiling, the cost of lubrication with the set described is less than with some other systems.

Some comparative costs may be interesting. They are, of course, based on English prices, but they may be taken as sufficiently good for comparison. Taking an ordinary accumulator electric light installation with a low-speed engine, the cost to run 200 12-c.p. lamps would be for engine, dynamo, battery, switchboard, etc., about $1,000. An engine and battery room 20 x 12 ft. would cost about $300, to which must be added $75 for concrete foundations, and $100 for erection, starting up the plant and charging up the battery, $1,475. Taking the Bruston set the cost of engine, dynamo, battery, switchboard, etc., is slightly more, being put down at $1,100, but no battery room is required; if there

(*Continued on page* 164)

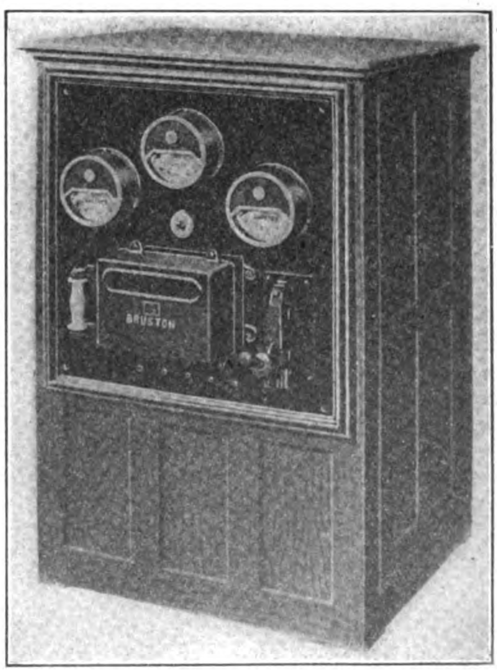



Fig. 3
Switchboard Cabinet

# THE CONSTRUCTION AND OPERATION OF THE GASOLINE ENGINE USED ON AUTOMOBILES

A. E. KLINE

The gasoline engine and its development has been one of the wonders of the mechanical age, and it is essential that the young mechanic has at least a fair conception of its construction and mode of operation. It is with this object in view that this article is written.

Gasoline is a colorless and comparatively light-weight liquid which is distilled from petroleum. It is a mixture of hydro-carbons, chief of which are known as pentane, hexane and heptane.

In order to become usable in the gasoline engine, it is mixed with air in a proportion of one to eighteen parts, in which it is vaporized. This vapor is then introduced into the working cylinders, where it is compressed from about 80 to 90 lbs. per square inch, at which pressure it is ignited by means of an electric spark. Due to the igniting of the mixture, combustion takes place, and the pressure rises to four times that originally. This pressure acts on the movable pistons, imparting to them mechanical energy in the form of a reciprocating motion. This motion is then transformed by certain means into rotary motion in order to be made use of.

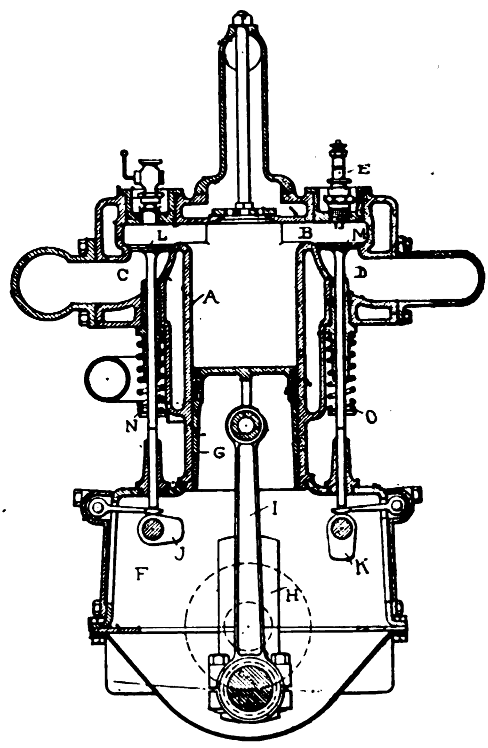



**Fig. 1**
**Sectional View of an Up-to-date Engine**

Before discussing the operation of the engine it is best that the various parts which constitute it be dealt with. A sectional view of an up-to-date engine is shown in Fig. 1. The cylinder *A* is a cylindrical casting of iron, at the upper portion of which, and cast integral with it, is what is termed the combustion chamber *B*. Two passages, *C* and *D*, communicate from the combustion chamber, and are termed the inlet and exhaust passages respectively. Each of these passages is controlled by a valve. One opens at the proper moment, and allows the mixture of gasoline to enter the combustion chamber, while the other allows the expulsion of the gases after they have been used. The spark plug *E*, used for the purpose of igniting the mixture, is usually placed in the combustion chamber. At the bottom end of the cylinder is what is termed the crank-case *F*, usually made of aluminum or cast iron, and so formed as to cover the moving parts of the engine. Within the cylinder is placed the piston *G*, which is usually a a hollow cylindrical casting of iron, closed at its upper end, and fits very closely in the cylinder bore. The piston is the portion of the engine acted upon by the gas pressure, and transforms the energy heat imparted to it into mechanical energy. The crank-shaft *H* is made of a horizontal steel bar, and is supported by bearings within the crank-case. At its middle point it is provided with an offset, which constitutes a crank. A rod *I*, called the connecting rod, is fastened, at its upper end, on a pin within the piston, while at its lower end it is fastened to a bearing on the crank. It will be seen that, as the piston moves down, due to the gas pressure, it imparts a rotary motion to the crank-shaft, through the intermediate action of the connecting rod.

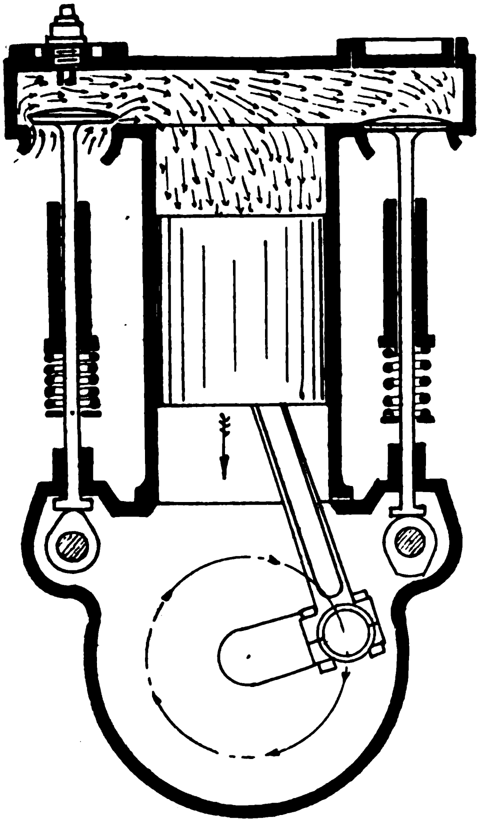


Fig. 2
Inlet Stroke

The valve mechanism which controls the entering and expulsion of the gases is clearly shown in the drawing. The cams *J* and *K* are rotated by suitable gears, and lower and raise the valves *L* and *M* at the proper moments, against the tension of the coiled springs *N* and *O*.

Having thus briefly referred to the principal parts of the engine, let us take up mode of operation. The great majority of engines are operated on what is known as the Otto cycle, deriving its name from the inventor, Dr. Otto, of Germany, who invented it in 1876. It is known as the 4-cycle type of operation. By a cycle is meant a succession of operations in an engine cylinder, with a single charge of explosive mixture. The four operations, or strokes, succeed one another in the following order:

1. Admission of the charge into the cylinder.
2. Compression of the fuel.
3. Igniting and expansion of the fuel.
4. Exhaustion of the burnt gases.

Each of these four operations occupies the time of one piston stroke. It is obvious that since one stroke of the piston occupies half a revolution of the crank-shaft, which is 180 degrees, the entire four strokes of a cycle, occupy 4 times 180 degrees which equals 720 degrees, or two revolutions of the crank-shaft. It will also be noted that in but one of the four strokes is power developed.

Figs. 2, 3, 4 and 5 show the four strokes diagrammatically. As before stated, the first stroke of the cycle is the admission stroke. The piston then moves outward in the cylinder causing a partial vacuum, and, due to opening of the inlet valve throughout this stroke, the gasoline mixture enters the cylinder from the vaporizing device known as the carburetor. At the end of the stroke, in fact a little after, the inlet valve is closed; the piston begins to move up, and compresses the charge in the combustion chamber. This is the second and compression stroke. When the piston has

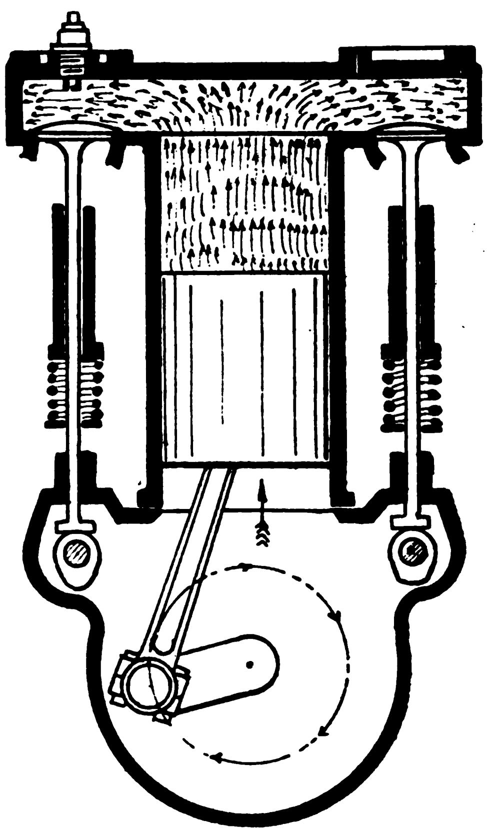


Fig. 3
Compression Stroke

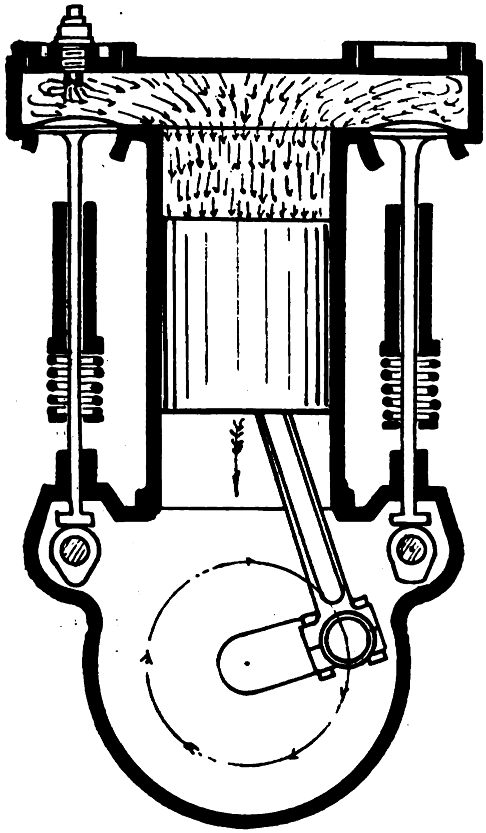


Fig. 4
Expansion Stroke

reached the end of its return stroke, the gas has been compressed to about one-fifth the original volume.

At or near the end of the compression stroke, an electric spark, produced within the compression chamber, ignites the compressed gas, and combustion takes place. The pressure immediately rises to about four times that previous. The actual pressure in the cylinder the instant of ignition is about 250 lbs. per square inch. Under this enormous pressure, the piston is forced downward, thus transforming heat energy into mechanical energy. The gas pressure drops rapidly as the piston moves outward, due to the increase in volume, loss of heat, etc. This is third and power stroke of the cycle.

When the power stroke is almost completed the exhaust valve opens, and the expulsion of the burnt gases continues throughout the following return stroke of the piston. This completes the fourth and last stroke of the cycle. On the next downward stroke a new cycle begins.

It is interesting to note the behavior of the gases in the cylinder throughout one cycle, and Fig. 6 readily shows this. This is a so-called indicator diagram, similar to those taken of a steam engine. The line 1-3-4 designates the inlet stroke, and shows the partial vacuum produced, since the line at point 3 drops below the atmospheric line. The compression stroke is shown by the line 4-5, and it can readily be seen how the pressure rises. At the instant of ignition the pressure increases enormously, as shown by the point 6, and, as the piston moves out, the pressure gradually drops again until the end of the stroke is reached. The line 1-2-4 shows the exhaust stroke, pointing out the fact that the gases are slightly compressed, due to the fact that the piston is sweeping them rapidly forward, and exerts a very slight pressure. As in a similar case of the steam engine,

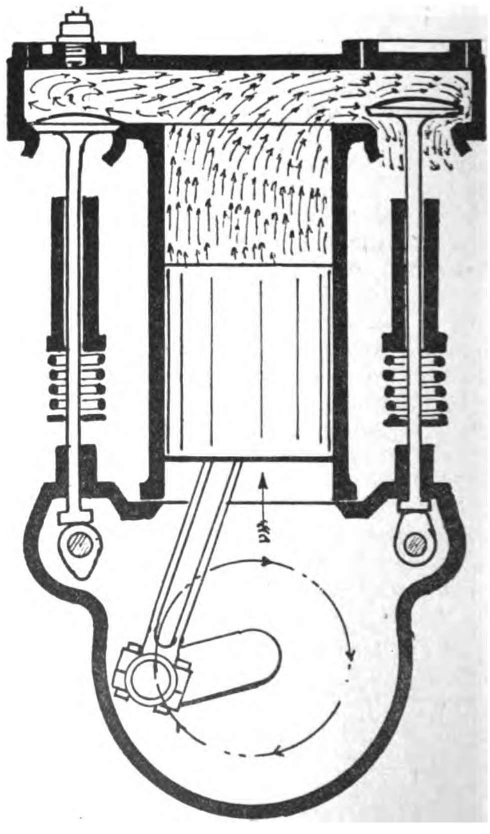


Fig. 5
Exhaust Stroke

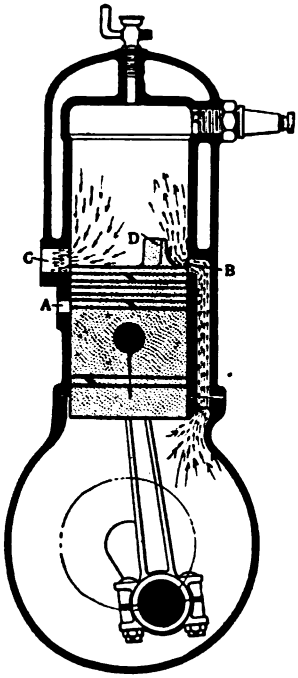



Fig. 7

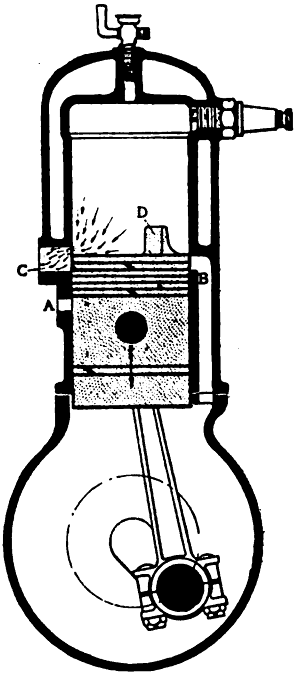



Fig. 8

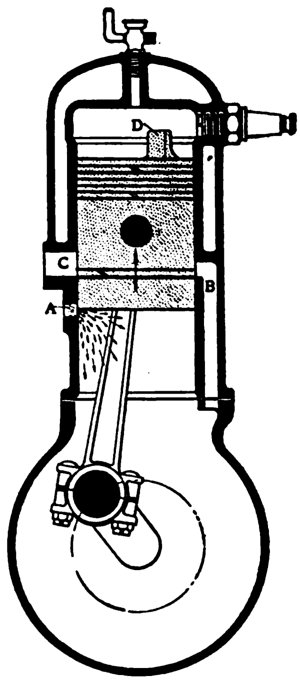



Fig. 8a

the area, 4-5-6, shows the amount of work done during the cycle.

Besides the 4-cycle engine, there is another form of engine in which the four operations, intake, compression, expansion and exhaust, are performed in but two strokes of the piston, or one revolution of the crank-shaft. This type is known as the 2-cycle engine. Figs. 7, 8

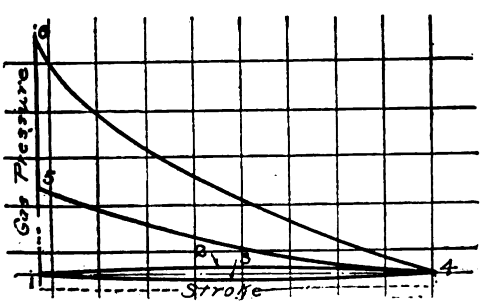



Fig. 6

and 8a show diagrammatically the operation, and also the essential parts.

The essential features of a two-cycle engine are as follows: An enclosed crank-case which is provided with a valve *A* which admits gas into it on the upward stroke of the piston. An inlet and exhaust post, *B* and *C* respectively, located at points near the extreme outward position of the piston, and a pass or connection between the crank-case and the cylinder.

The operation is as follows: Assuming the piston to be moving upward, and is compressing a charge. As it travels up,

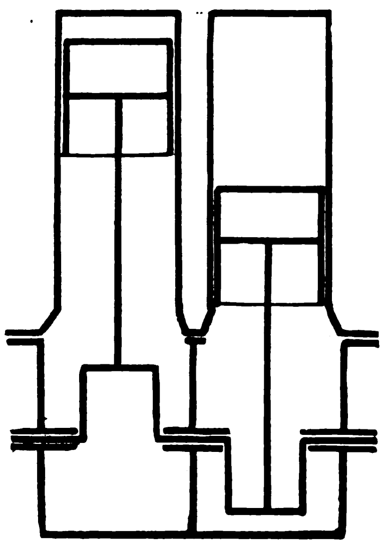


Fig. 9
Twin Cylinder Type

it uncovers the post *A*, Fig. 7, and gas enters the crank-case. The compressed fuel in the cylinder is ignited, expands, and the piston moves down. As it does so, it shuts off connection between the crank-case and cylinder by covering the valve *B*, and hence it compresses the gas in the crank-case. As it reaches the end of the downward stroke, it opens the exhaust post *C*, and a trifle later connection is made between the cylinder and crank-case, shown in Figs. 8 and 8*A*. The burned gas exhausts, and the gas in the crank, being compressed to about 35 lbs., rushes into the cylinder, as shown

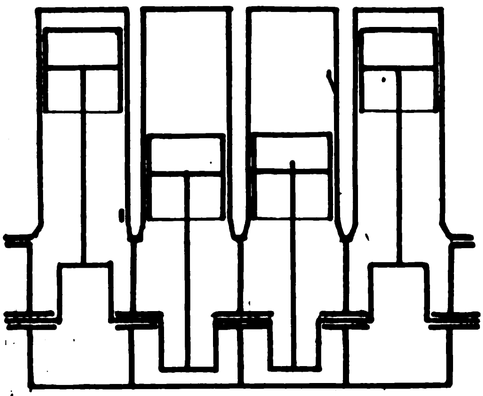


Fig. 10
Four-Cylinder Type

The piston now moves up, closes both posts, and compresses the gas above, and at the same time, a new charge enters the crank-case. The compressed gas in the cylinder is now ignited, and the piston is forced downward again.

The result is that two operations are done in every stroke; on the down stroke expansion and compression, and on the up stroke, intake and exhaust.

The chief advantage of the two-cycle engine over the four-cycle evidently lies in its simplicity, as there is a total absence of valves, cams, springs, etc. The other advantage lies in the fact, one power impulse is received for every two strokes, as compared with but one power impulse for every four strokes. Hence theoretically the two-cycle engine should develop twice the power of a four-cycle, other dimensions being equal. Such is not the case, however. In actual practice hardly twice the power is developed, due to various reasons which cannot here be dealt with.

It is an evident fact that the amount of power developed by an engine depends upon the number of cylinders, other things being equal. The average single cylinder engine develops from 6 to 12 h.p. The majority of engines employed for automobile work have more than one cylinder,

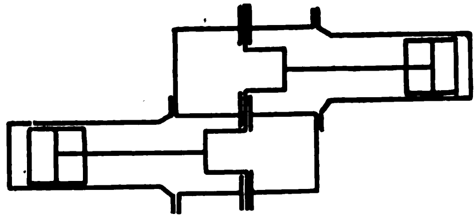


Fig. 11
Double-Opposed Type of Engine

in order to develop more power, and it may be of interest to study the methods of grouping the cylinders.

Fig. 9 shows a twin cylinder type; Fig. 10, a four-cylinder type, and Fig. 11 what is termed a two-cylinder double-opposed type. While the casting of these cylinders is quite a problem, yet there are engines manufactured at the present time which have all four cylinders cast integral, and there is also a six-cylinder type, which has just been announced, that has all six cylinders cast integral.

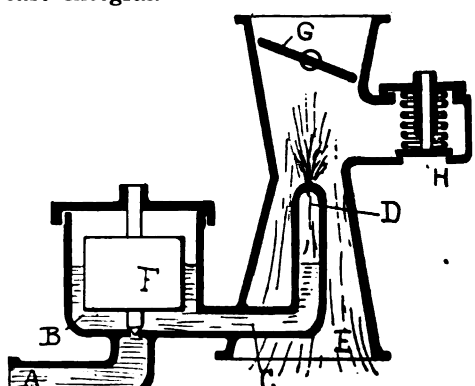



Fig. 12
Diagram Form of Carburetor

It may be well to examine the method of vaporizing the gasoline before it enters the engine cylinder. The carburetor, or vaporizer, as it is sometimes called, is used for this purpose. Fig. 12 shows a very simple type in diagram form.

The gasoline in liquid form enters at the opening *A*, and into a reservoir *B*, from which it issues through a channel *C*

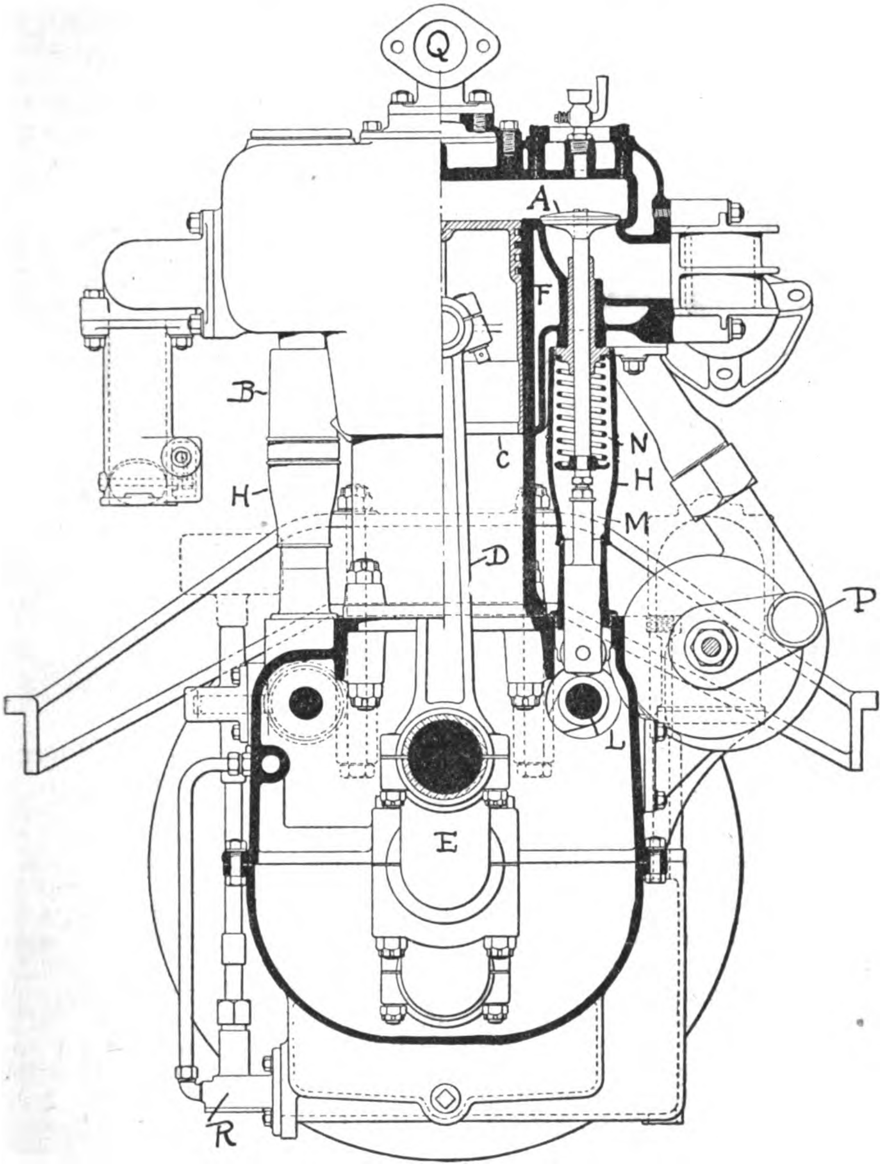



Fig. 13

into the tube *D*. As it leaves this tube, or nozzle, as it is called, it is mixed with the air, which enters at *E*, and vaporized. The vaporized mixture then passes up the chimney and into the engine cylinder. The float *F* serves the purpose of keeping the gasoline in the reservoir at a constant level. A valve *G*, called a butterfly valve, serves the purpose of regulating the amount of mixture entering the engine. The valve *H* is for the purpose of adding additional air to the mixture.

As before stated, the explosive mixture is ignited by means of an electric spark, which is produced by the well-known magneto, which is a form of dynamo generator. It generates the current, transforms it to a high pressure, or voltage, and distributes it to the various cylinders.

Having familiarized ourselves with the fundamental parts and principles of operation, let us examine a well-known type of engine, and discuss it in detail. This engine, shown in Figs. 13 and 14, will be seen to have four cylinders, cast

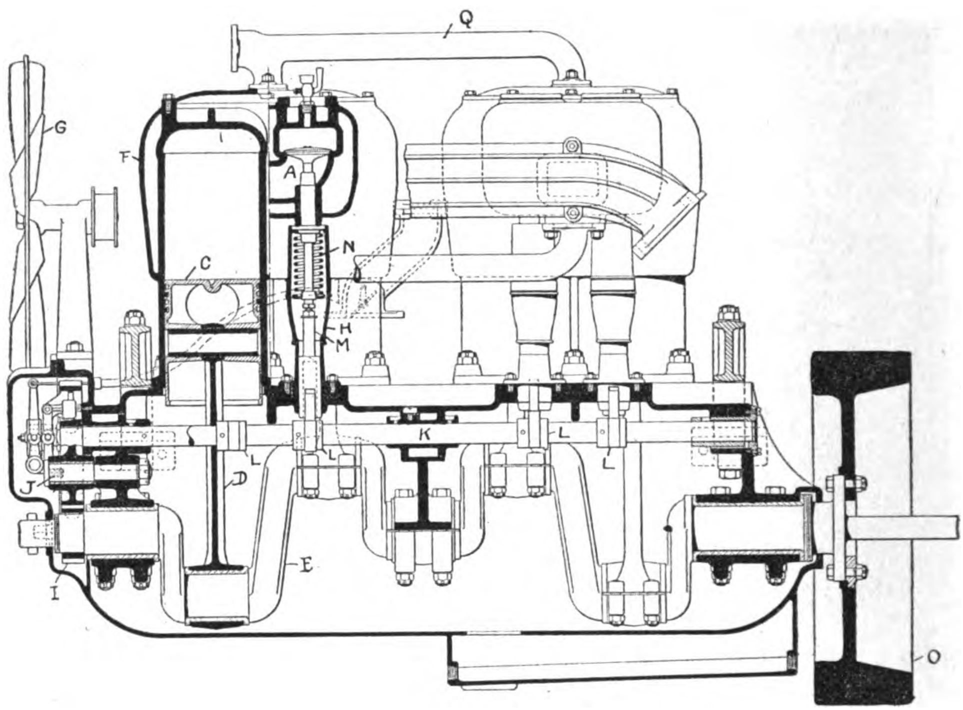



Fig. 14

in pairs, with the valves *A*, *B* on opposite sides. This type of cylinder is termed a T-type, as it resembles the letter T. But one of the valves *A* is shown fully. The piston *C* is fastened to the connecting rod *D*, which in turn is fastened to the crank-shaft *E*. There is a jacket *F* cast about the cylinders, through which water circulates, for the purpose of carrying off the tremendous heat generated by the explosions. A fan *G* also helps to cool the cylinders. The valve stems and springs are encased by the casing *H*, which protects them from the dust. The gear *I* is keyed to the crank-shaft *E*, meshes with the gear *J*, which turns the cam-shaft *K* and consequently *L*. The cams operate the valve push rods *M* against the springs *N*, which operate the valves. The flywheel *O*, which is bolted to the rear end of the crank-shaft, is for the purpose of producing an even turning motion. A pump *P* continuously circulates the water through the water jackets and into the radiator by means of the outlet pipe *Q*, and an oil pump *R* continuously pumps the oil to the various bearings, where lubrication is required.

Figs. 15 and 16 are actual photographs

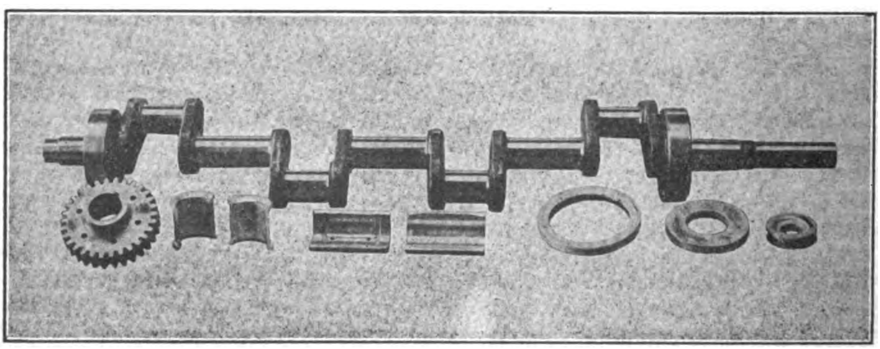


Fig. 15. Crank-Shaft and Bearings

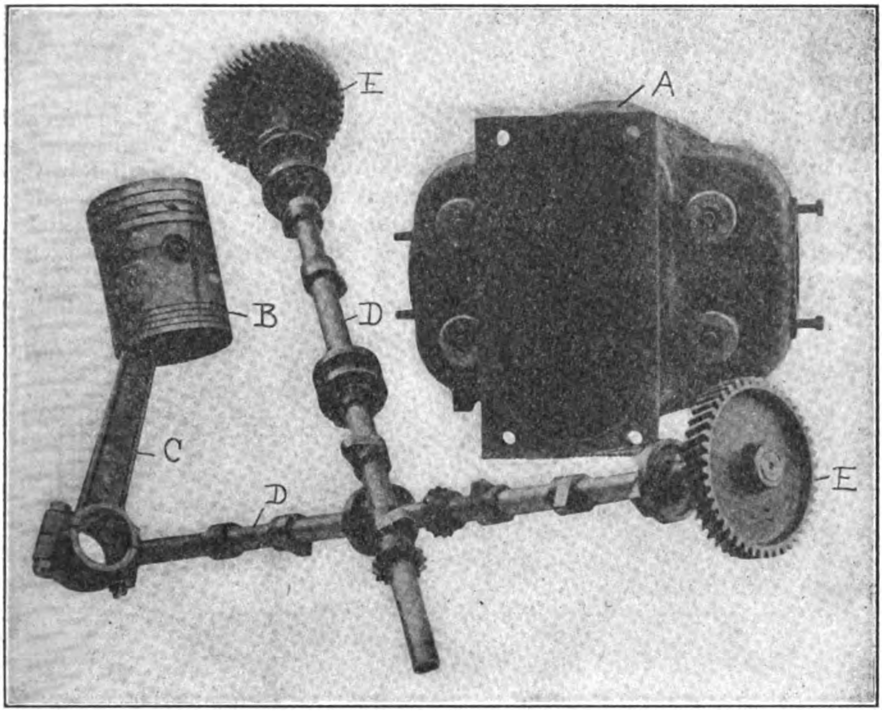



Fig. 16. Piston, Cam-Shaft and Connecting Rod

of the various parts, and are inserted so as to help the reader to more readily grasp the general appearance of them. At *A*, in Fig. 16, is shown the lower portion of a twin type of cylinder; at *B*, a piston; at *C*, the connecting rod; and at *D*, *D*, two cam-shafts. The helical gears *E*, *E*, which are keyed to the ends of the cam-shafts, are for the purpose of driving them from the crank-shafts. At Fig. 15 is shown the crank-shaft of a four-cylinder engine, with its bearings and the gear which meshes with that on the cam-shaft.

At Fig. 17 is shown the manner in which the pistons, connecting rods and crank-shafts are assembled in a four-cylinder engine.

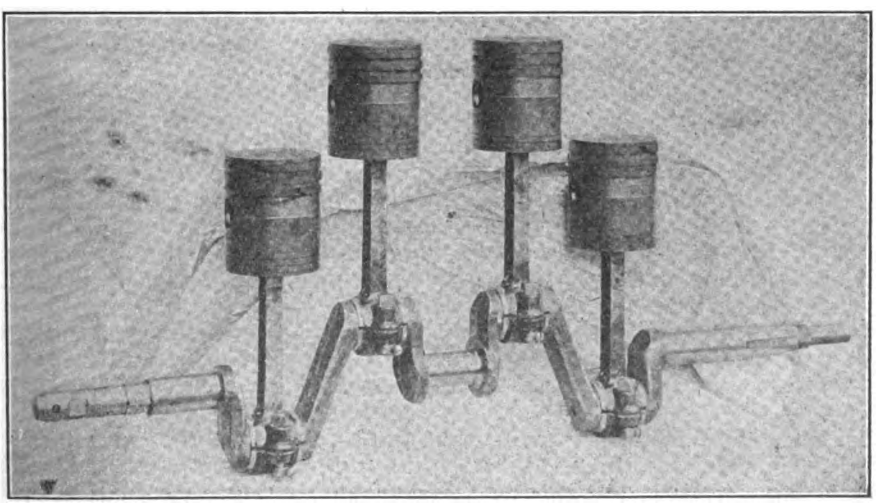


Fig. 17. Crank-Shaft and Pistons

# X-RAY APPARATUS OF TODAY

H. WINFIELD SECOR

When the X-ray was first introduced as an accessory to the surgeon and physician, to aid in locating foreign bodies, diseased bones, etc., in the human body, it was usual to operate the X-ray tubes from a static machine, probably because it was a ready source of high-tension direct current at that time.

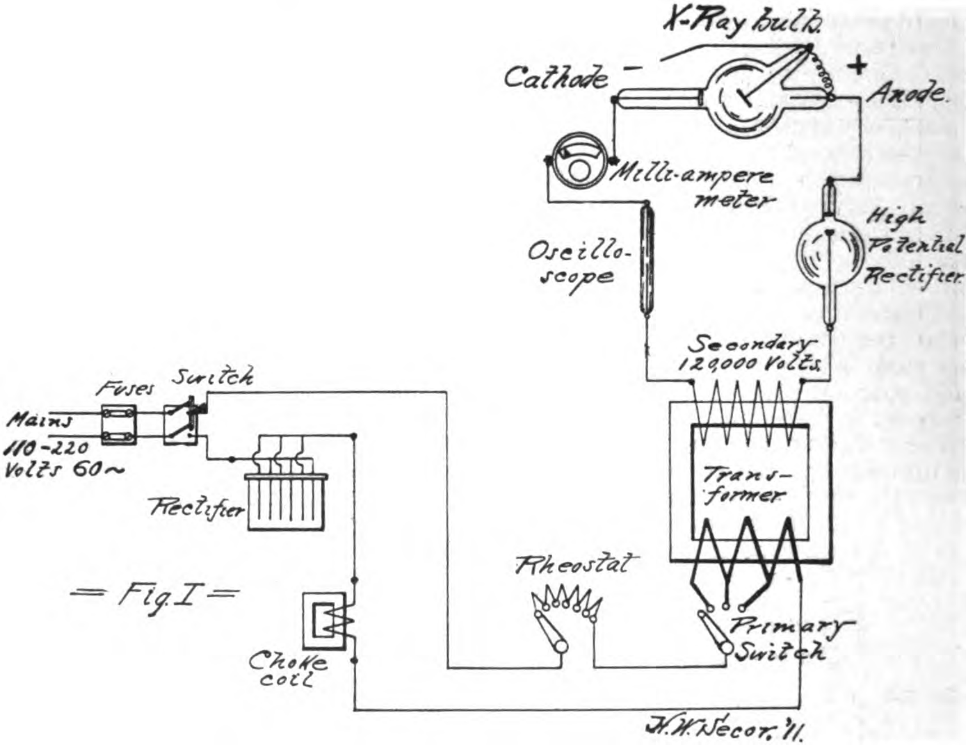



Diagram for the Production of a High Potential, Unidirectional Current

But it was not long before dissatisfaction began to be manifested among the users of these machines for exciting the X-ray tubes, and the most frequent cause given was, that in damp or warm weather it was oftentimes impossible to make the static machine generate a sufficient current, and sometimes none at all. Another point against static machines, is that their current capacity is rather limited, also, they are quite unsteady in the supply of current.

Then came the wave of popularity for the induction coil, as a source of X-ray current. This seemed to be a great boon, as it was always ready to deliver a powerful discharge, of practically unvarying intensity; but its serious disadvantages, which unsuited it to some extent for this work, were the frequent adjustment and care of the interrupter, and the secondary current, which, being an alternating one, although not harmonic, had the undesirable half wave, caused at every make of the primary circuit, and known as the inverse current, which caused the X-ray tubes to have a greatly shortened life, owing to this inverse current, tending to make the anti-cathode or anode electrode the cathode, with a consequent scattering of the platinum forming the target or anode.

Thus what was wanted was a source of current which should demand practically no attention after once adjusting; absolute constancy in service, allowing the full value of the current to be had at any time, and this current should be a unidirectional or direct current, with no inverse or reverse current, whatever.

These qualifications of a satisfactory X-ray machine seem to have been fulfilled in the apparatus built by the Kny-Sheerer Co., of New York City. They build several different types of this apparatus, and as they represent the very latest in this field, they will be described in order. All of this apparatus employs a closed core, high potential, step-up transformer of high efficiency, in place of the less efficient open core induction coil.

The simplest set for the production of a high potential unidirectional current is illustrated in diagram I, and is connected directly to any 110 or 220 volt 60-cycle alternating current circuit. Use is made of a regular electrolytic rectifier, placed in series with the main line feeding the transformer, which suppresses one-half of every wave, allowing the current to flow through it in one direction only, resulting in an unidirectional current flowing through the primary circuit of the closed core transformer. The rectifier is composed of alternate iron and aluminum plates immersed in a saturated solution of bi-carbonate of soda. As shown in sketch, a variable resistance is placed in the primary circuit to vary the intensity of the secondary discharge, also a choke coil. The primary winding is adjustable in several steps, making the outfit very flexible in its operation.

The secondary voltage is variable between 20,000 and 120,000 according to the amount of primary turns and resistance inserted into circuit. At the latter voltage the secondary discharge takes the form of a heavy spark, or rather flame, 11 to 12 in. long. To further improve the unidirectional qualities of this current, a high potential rectifier, having two electrodes sealed in a glass bulb, containing a partial vacuum is placed in series with the positive terminal of the secondary circuit and the positive electrode or anode of the X-ray bulb. The negative or cathode of the X-ray tube is connected to an oscillioscope, thence to a milliampere meter, and from this to the negative terminal of the secondary coil.

The oscillioscope, referred to above and seen in diagrams, is composed of a glass tube about 1 in. in diameter and 7 in. long, having two aluminum wires secured in it, with a short gap left between their ends. The tube is evacuated, and the presence of any inverse current in the X-ray circuit is indicated by the

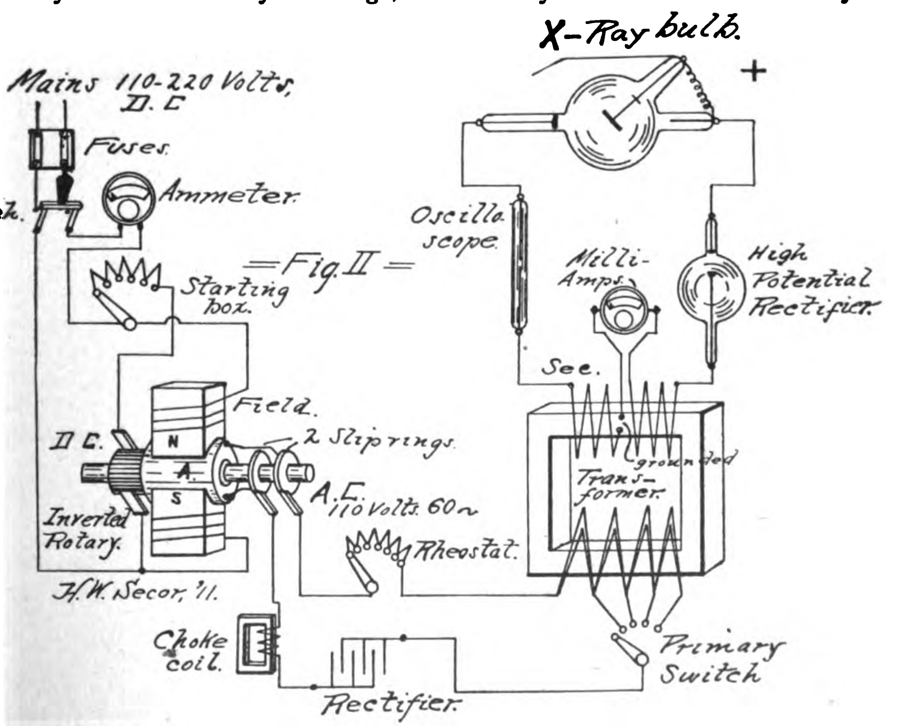



Diagram of a Set which is to be operated from a Direct Current Circuit

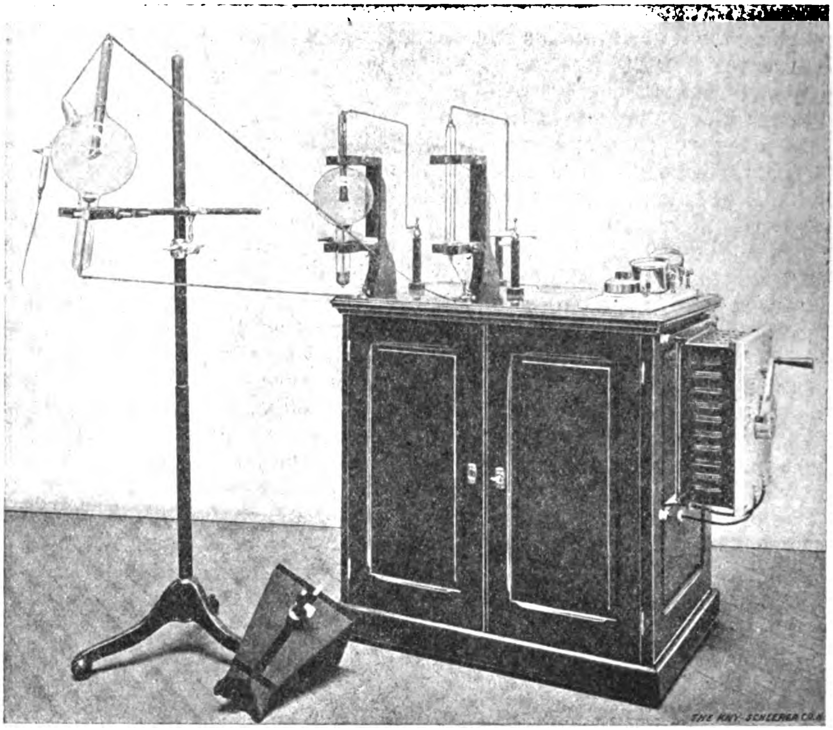


Fig. 3
X-ray Current Generator

fluorescence in the tube, extending along both wires, but if the current is flowing in one direction only (as it should), then the band of fluorescence extends only around the negative pole or electrode.

This scheme of producing a high-potential unidirectional current is quite satisfactory, but has certain disadvantages, *viz.*, the rectifier requires some attention, besides being wasteful of current, and the high-tension valve tubes, inserted in series with the anode lead, are subject to wear and tear, and must be renewed at intervals.

A set of this type designed to operate from a direct current circuit is illustrated by diagram Fig. 2. Here an inverted rotary converter (which is simply a D.C. motor with two slip rings attached to one end of the armature and connected to the regular winding) is utilized to run as a shunt motor and deliver the necessary A.C. from the two slip rings to excite the step-up transformer. The electrolytic rectifier, choke coil and variable resistance are inserted in the primary circuit, as in the set used for A.C. circuits described above, and the rest of the diagram remains the same.

The appearance of this type of X-ray current generator is seen in Fig. 3, while Fig. 4 shows a high-potential rectifying tube, which is utilized to suppress the inverse half wave of oscillating currents. It acts the same as the iron-aluminum rectifier in low-potential circuits, *i.e.*, it allows the current to flow through it, in one direction only.

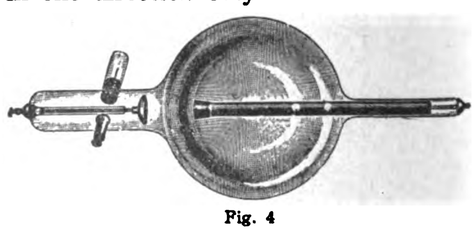


Fig. 4
High-potential Rectifying Tube

This machine, although much superior to the induction coil, with its attendant interrupter troubles and undesirable secondary alternating current, left a few points to be desired yet, and so, as "necessity is the mother of invention,"

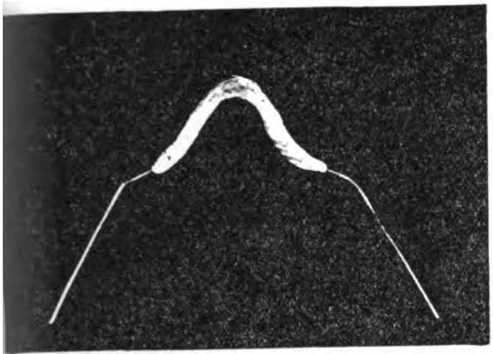


Fig. 5
An Interrupterless Set

a more improved type of generator was produced, which is certainly a remarkable machine.

As a starter, ask someone you know, if they ever saw 120,000 volts alternating current commutated into 120,000 volts direct current, and I'll wager 99 out of every 100 will look askance at you. Yet this is what this improved type of X-ray machine is capable of doing, and it is known as the unipulsator, or "interrupterless," the latter being the trade name for it.

It is regularly built in the 4.4 k.w. size, for operating either on D.C. or A.C. circuits. The high-potential unidirectional current used for the X-ray tubes may be varied from 20,000 to 120,000 volts, giving a very heavy flame discharge 12 in. or more long at the latter voltage, the appearance of the flame being illustrated in Fig. 4.

In the cut at Fig. 5 is depicted an "Interrupterless" set, complete, and designed to be operated on alternating current, single or polyphase. It is also regularly built for direct current circuits of 110 to 220 volts.

The general layout and scheme of such a set, designed for direct current circuits, is shown in Fig. 7; the scheme remaining the same for alternating current circuits, with the exception that the inverted rotary converter has its place taken by a synchronous A.C. motor and starting motor, with the necessary synchronizing devices, or an automatic self-starting

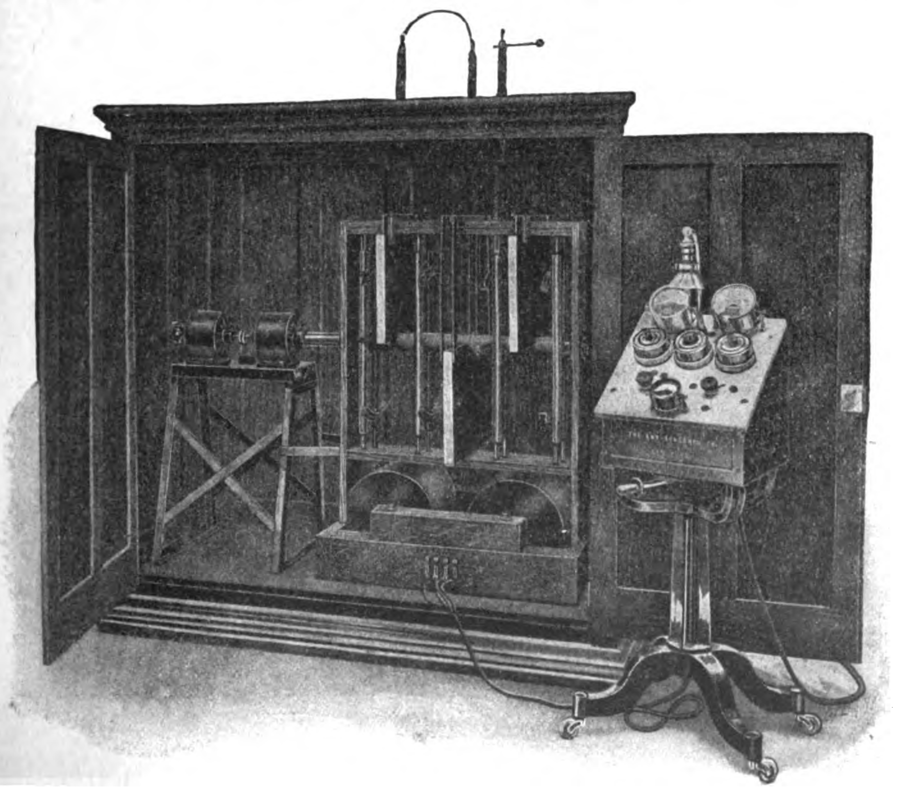
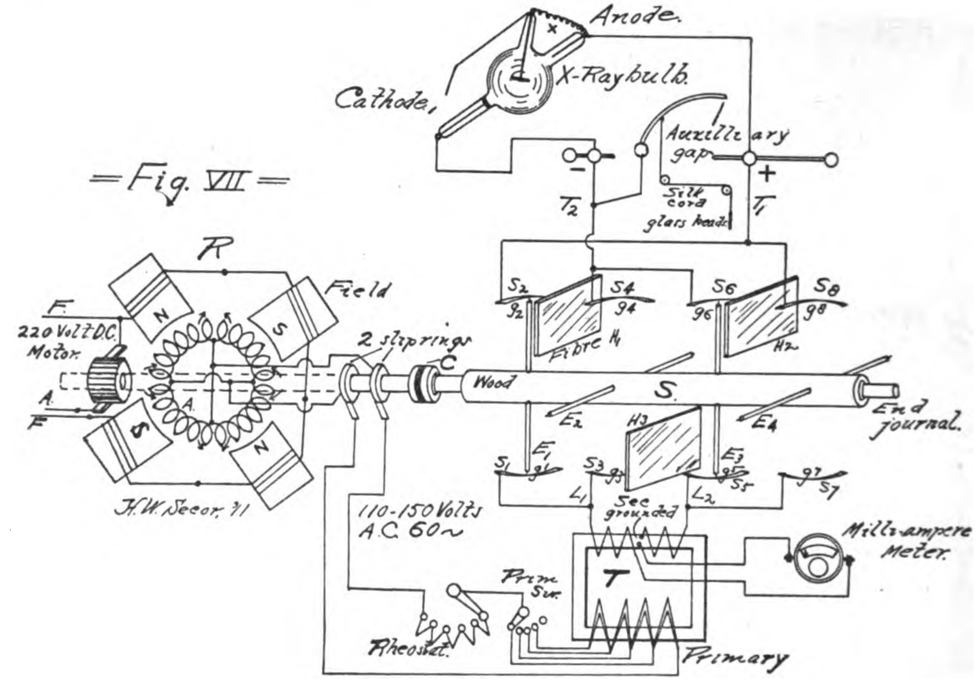


Fig. 6




General Layout for D.C. Supply Circuits

and synchronizing motor embodied in one machine.

With A.C. supply circuits at hand, the A.C. motor, used to drive the high-potential rectifying spindle and arms, may be a small affair, about ¼ to ½ h.p. The transformer takes its quota of A.C. direct from the mains. The position of the rectifying arms, in relation to the reversals of the alternating current, is assured by the utilization of the synchronous motor, which runs in step with the alternators, feeding the circuit.

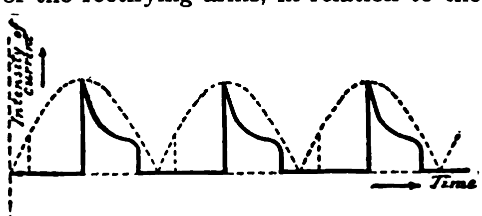



Fig. 8

The general layout for D.C. supply circuits is given in Fig. 7, where *R* is an inverted rotary converter running as a D.C. motor and delivering A.C. from its two slip rings to the primary of the step-up transformer *T*. The D.C. motor circuit includes a regular starting box for shunt motors, an ammeter, and sometimes a field rheostat, although not shown here. The primary circuit to the transformer has inserted in it, a variable resistance box (but preferably a variable inductance), and a multipoint switch to change the number of primary layers in use, and by these means, the secondary current may have its tension adjusted to any desired value up to **120,000** volts, which is sufficient to excite the largest X-ray tubes to their highest efficiency.

We now come to the ingenious device used to commutate the high-tension alternating current coming from the secondary of the transformer into a unidirectional or direct current.

This is made up of an ebonite or hardwood shaft *S*, coupled onto the end of

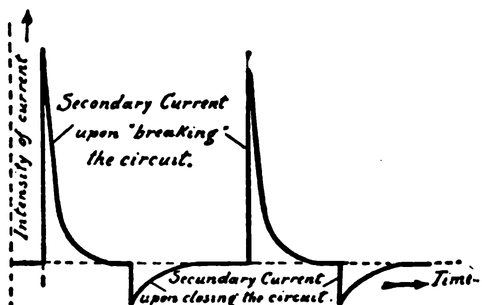
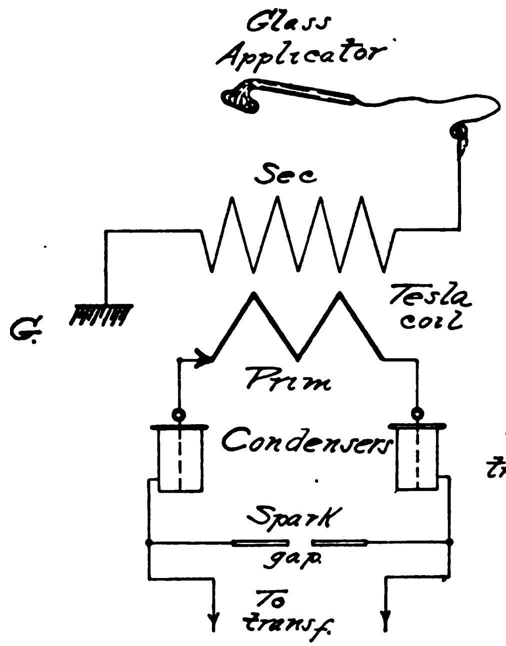
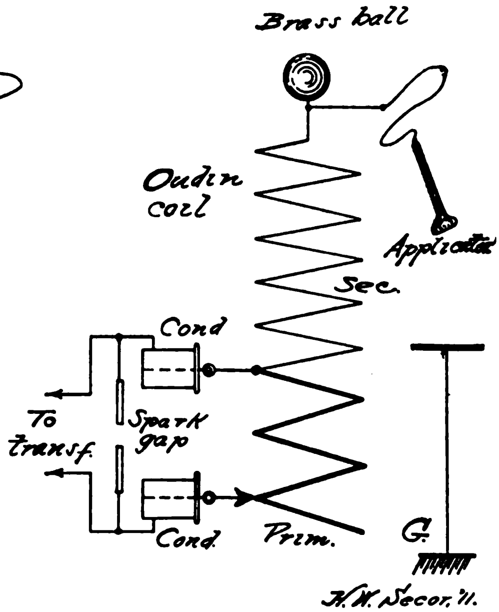



Diagram of the current in a tube supplied by an Induction coil.

Fig. 9




=Fig. X=




=Fig. 11=

the rotary converter shaft by an insulated coupling $C$, and hence rotates in step or synchronism with the rotary armature. This shaft $S$ has four ebonite rods, with conductors running through their centers, $E_1$, $E_2$, $E_3$ and $E_4$, pierced through it crosswise at 90 degrees apart, as shown.

Above and below this shaft, are placed 8 metal segments electrically connected to the transformer secondary and the X-ray tube terminals, in the manner depicted.

Taking the inverted rotary converter as a quadrupolar machine, we will have two complete cycles of alternating current, four alternations: two positive and two negative, at every revolution of the rotary armature and rectifier shaft $S$. Now the ebonite cross rods must be set by experiment or otherwise, so that when a positive impulse, or the positive half wave of a cycle is emitted from the secondary of the transformer, along the lead $L_1$, to segment $S_1$, that the impulse may travel a minute gap at $g_1$, along the ebonite covered electrode $F_1$, over the second gap $g_2$, and so to the positive terminal of the machine. The negative current flows over the secondary lead $L_2$, the two small gaps, $g_5$ and $g_6$ and the negative terminal wire $T_2$.

During the next quarter-revolution of the armature and shaft $S$, and while the negative impulse or half-wave of the cycle is flowing from the secondary coil over the lead $L_1$ (remembering that the transformer supplies an alternating current), the cross electrode $E_2$ has connected segments $S_3$ and $S_4$ together, through the two small gaps $g_3$ and $g_4$, leading the current to the negative terminal of the apparatus, while the positive current flows over the lead $L_2$, to segment $S_7$, gaps $g_7$ and $g_8$, segments 8, and positive terminal $T_1$; so it will be seen that the current is kept continually directed in one direction or it is changed from an alternating current to a unidirectional or pulsating direct one.

The pole changing parts are of necessity extremely well insulated, and have the fiber or hard rubber partitions $H_1$, $H_2$ and $H_3$ placed between parts of opposite polarity, where there is most liable to be a jump made by the current.

In some types of this class of apparatus the ends of the cross-wise electrodes have spring bush contacts fitted upon them, so that the current does not have to jump the small gaps, which occasion quite a little loss, as several thousand

(Continued on page 198)

# A TINY WATTLESS H-CORE TRANSFORMER

## How to Make a Small Step-Down Transformer for Ringing Doorbells, Lighting Small Lamps, etc.

PHILIP EDELMAN

The title of this article is perhaps a trifle misleading, since the output of the transformer is in reality about 5 watts. However, when it is remembered that this transformer is for use with 110 volts a.c. current it will readily be seen that only a very small current is required to operate the primary circuit. The current is in fact so small that it will not register on most meters,—therefore the above name. It may be left connected to the line all the time with safety, and for all purposes where only a small current is required, it is the cheapest source of current that I know of.

### GENERAL PRINCIPLES

In its simplest form a transformer is very much like an ordinary induction coil. (See Fig. 1). The core is generally in the form of a ring or a modified ring, so that the magnetic lines of force can have a continuous iron path. Referring to the figure. Suppose the primary *P*

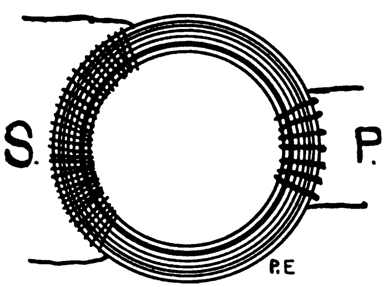



Fig. 1

has ten turns of wire, and the secondary winding *S*, one hundred turns. Then, if an alternating current is sent through the primary coil, an alternating current of just ten times as great a voltage and only one-tenth as great in amperage will be induced into the secondary coil. This is known as a step-up transformer. Now if the primary coil is regarded as the secondary and the secondary coil is connected to a source of alternating current, the current induced in the other coil will be only one-tenth as high in voltage as the primary coil, but ten times as strong in amperage. The transformer in this case is a step-down transformer. Of

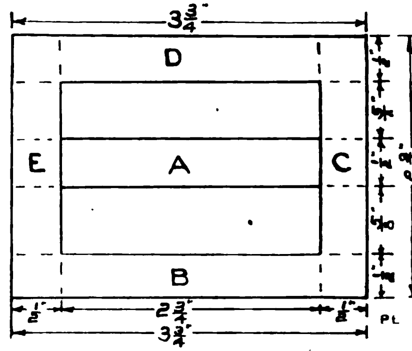



Fig. 2

course the sizes of the wires would have to be proportioned in practice to conform with the relative currents, as well as proportionate insulations and other items. Since watts equal the voltage times the amperage, it will be seen that the wattage remains the same in both the secondary and primary, if there are no losses. Among the losses the chief items are magnetic losses, and losses caused by the heating of a transformer.

### CONSTRUCTION

*The Core.*—The foundation of the transformer is the core. It would be difficult to wind a large number of turns of wire on a round core as illustrated in Fig. 1, so a modified closed core is adopted. The core to be used in this little transformer is known as a modified H core. In this type of core the two windings are wound on the middle leg *a*, Fig. 2, and then surrounded with an iron shell, *b*, *c*, *d*, *e*.

From some soft sheet iron (stovepipe iron) or some soft sheet steel, cut up a pile of strips ½ in. x 3¼ in. for the middle leg *a*, until the strips form a pile ¾ in. high when compressed. Enough scrap sheet iron can usually be found around a tin shop from which to cut these strips. The cutting should be done with a foot-operated square shears. In a like manner cut up a pile with the dimensions ½ x 3¾ x ¾ in. high, for the two outside legs *b* and *d*. Only the one pile is needed for the two parts. For the parts *e* and *c* cut up one pile only ½ x 2¾ in. and ¾ in. high.

Assemble the strips for the leg *a*, as shown in Fig. 3. Before assembling the strips they should be coated on one side with a thin solution of orange shellac. It will be seen from the figure that each strip is laid so that it projects ½ in. on either side. The strips are thus arranged alternately with projections of ½ in. on each side. The pile should then be held in place by binding it with an evenly-wound layer of tape. In this taping, do not tape the ½ in. projections on each side. The other piles are left alone for the present.

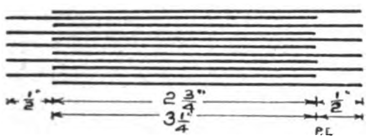



Fig. 3

*The Windings.*—The primary for this coil will necessarily have a large number of turns of wire. In order to get them all in the small place, it is necessary to use fine wire evenly wound. Since the current which it is to carry will only be a fraction of an ampere, the wire need not be any coarser than No. 34 B.&S.

Make a spindle, Fig. 4, on which to wind the wire. Make a piece out of wood ½ x ¾ by 4½ in. long. Center it and place it in a small lathe or place it so that it may be easily rotated in some manner. On this spindle first wind a layer of common string. Then wind on five or six layers of heavy paper. Over this wind three or four layers of shellacked paper and a layer of friction tape. The shellacked paper and the friction tape should only be wound a distance of 2½ in. on the middle portion of the spindle.

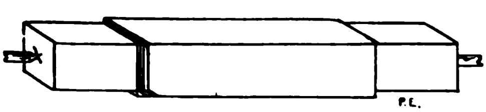



Fig. 4

Over this tape wind another two layers 2½ in. wide of shellacked paper. All this is to insulate the windings from the core. It would never do to have any grounds on the core metal. This done the winding of the wire comes next. Get 1 oz. of No. 34 enameled wire (full weight) and wind it on the central portion as evenly as possible. Be sure to keep within the 2½ in. covered by the shellacked paper. To aid in doing this it is a good plan to fasten little guide blocks on the spindle. It is also well to put a layer of shellacked paper between each three or four layers of the winding. When all the wire is wound on, the primary winding should be covered by alternate layers of tape and shellacked paper, as was done before winding on the primary wire. It would ruin the transformer if a short circuit were to take place between the secondary and transformer in many cases. It would also spoil any low voltage apparatus that happened to be connected to the secondary winding. Unpleasant shocks might also result. Great care should therefore be taken to have plenty of insulation.

The secondary winding consists of three sizes of wire. The first winding is of No. 22 magnet wire. Wind on one hundred turns evenly. Leave an end

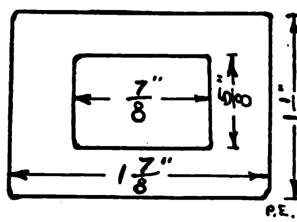



Fig. 5

of several inches for connections. Over this wind a second hundred turns of No. 24 magnet wire, leaving enough wire on the ends for connections. The third winding is of No. 26 wire, and is wound over the other two. This last winding has one hundred and fifty turns. About 40 ft. each of the No. 24 and No. 22 will be needed, and about 60 ft. of the No. 26. The windings should be arranged as evenly as possible. The ends of the three (No. 22, 24, 26) windings are attached together, the end of the first to the beginning of the second, etc. This arrangement allows of a choice of three voltages on the secondary. Test the coils for short circuits or grounds, using a telephone receiver and dry battery. If a defective coil is found it should be rewound. The whole should then be taped with some good friction tape and removed from the spindle. To remove the coil from the spindle, first pull out the string which was wound on at first. The windings will then come off easily.

*Assembling.*—The completed windings

Fig. 6

are slipped over the pile *a* next. Cut out some pieces from fiber 1/8 or 1/16 in. thick, in the shape shown in Fig. 5. One of these washers is slipped on each end of the core and winding. The pieces *e* and *c* are then fitted between the projections of the piece *a*, and then the pieces *d* and *b* are meshed in between the ends of the pieces *e* and *c*, and the whole nicely squared up. The whole shell will thus be like a grate bar. The core is held together by two clamps, one on each end. See Fig. 6. These clamps are made out of strips of iron 1/8 in. thick and are cut out 1/2 x 3 1/2 in. Four pieces are needed for the two clamps. One-eighth inch from each end a 3/16 in. hole is drilled.

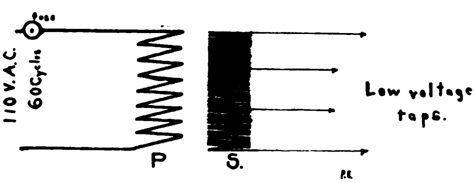



Fig. 7

The core should be clamped in a vise or clamp and then the clamp just made should be arranged on it and screwed down. The screws are made by threading four pieces of 3/16 in. rod. The nuts should be turned as tight as is possible.

The transformer thus made may now be mounted in a suitable metal box and the proper connections made (see Fig. 7). It would be well to include a 1/2 ampere fuse in the primary circuit. In mounting the transformer the primary and secondary ends should be brought out to binding posts on opposite ends of the box. The secondary terminals being of low voltage need not have much insulation, but the primary terminals must be well insulated from the metal box. While the secondary may be overloaded or even short circuited without harming the transformer, it is well to use it only on normal loads.

When used as a doorbell ringing transformer, the same wiring that is used with batteries may be used. When the secondary is on open circuit, the current consumed is practically nothing, on account of the high reactance of the primary winding.

WARNING: Never connect the secondary of this transformer direct to the line. It is only a step-down transformer and would burn up if the primary current were sent through the secondary.

## Electric Lighting In Private Installations

(*Continued from page* 147)

are no concrete foundations, the erection costs are negligible, as the plant is self-contained and the cost of the engine room, erection and starting up can be put down as $55, giving a saving over the former method of $320. With regard to working costs, the ordinary accumulator system the approximate labor costs of running the plant, cleaning, charging batteries would work out at about $180 in England, to which must be added 12 1/2 percent depreciation of the battery equal to $35 per annum. In the Bruston system the approximate labor and battery depreciation are insignificant; $15 would cover it. The annual saving in running cost would, therefore, work out at about $200. It will, therefore, be seen that for country locations, in particular. this system offers possibilities which render it very interesting.

Some of the steamships supplied with Marconi Wireless Equipment landing and departing to and from this country are as follows: *Rotterdam*, *Kronprinzessin Cecilie*, *Lusitania*, *La Bretagne*, *C. F. Tietgen*, *Baltic*, *George Washington*, *St. Paul*, *Berlin*, *Minmewaska*, *Cameronia*, *Ryndam*, *Finland*, *Kaiser Grosse*, *St. Paul*, *Celtic*, *La Provence*, *Campania*.

Messages for any of the boats are handled through any telegraph office, in a similar manner as the manipulation of a telegram.

"Why have you painted your sign upside down?"

"I carry aviation goods; I want it so that the birdmen can read it as they fly overhead."—*Washington Herald*.

# ENGINEERING LABORATORY PRACTICE—Part IV

## The DeLaval Steam Turbine

P. LEROY FLANSBURG

In a book written by Hero of Alexandria, more than two centuries before Christ, were described the first steam engines of which we have any knowledge. Many of these engines were very ingenious, but they were of no practical use, and it was not until 1693, that the first commercially successful steam engine was made. This engine was built by Thomas Savery, and, compared with our engines of today, it was very wasteful of steam. The pulsometer, which is still in quite common use, is a modification of this early engine. After Savery, much work was carried on by Newcomen and Watt in developing the steam engine, and in 1829, George Stephenson built the "Rocket," which was the first successful steam locomotive. While there have been many mechanical improvements made upon the steam engine since the time of Watt, there has been but one thermodynamic improvement made in the reciprocating engine, namely the use of compound expansion types of engines.

Among the earliest of the steam engines is the one known as the Hero engine. This engine consisted of a hollow sphere so mounted that the steam entered the interior of the sphere through one of the supports, and was allowed to escape through pipes bent at right angles to a diameter, as shown in Fig. 1. The reaction of the escaping steam caused the sphere to revolve upon its supports.

In 1882, Doctor Gustaf De Laval invented a turbine based on the same principle as Hero's engine. It consisted of two curved hollow arms attached to a shaft and the passage of steam through the arms caused them to revolve, thus rotating the shaft. This shaft drove a second shaft at a slower speed by means of friction wheels. De Laval invented this turbine for the direct driving of cream-separators, and many such are still in use. Seven years later De Laval patented in Great Britain a turbine wheel combined with a diverging nozzle and the steam was allowed to expand in the nozzle and was then directed against the turbine buckets. Shortly after the in-

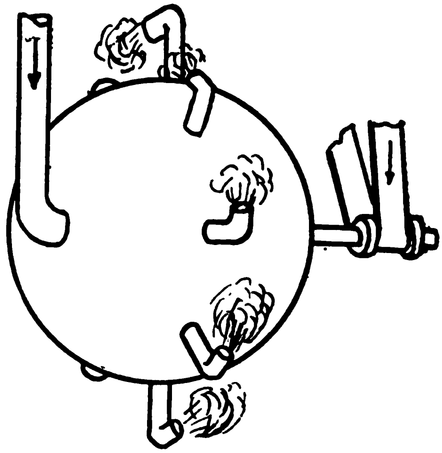


Fig. 1.

vention of the De Laval turbine, another type of turbine was introduced by Parsons. The difference between the two lies chiefly in their methods of utilizing the expansive force of steam.

A turbine is essentially a machine in which rotary motion is obtained by a gradual change of the momentum of a fluid. The change of momentum produces, or is equivalent to a force, and it is this force which causes the turbine to rotate against the resistance of the load. In steam turbines, the expanding steam produces kinetic energy of the steam particles, and the total energy given up by the steam is thus converted into kinetic energy. Usually several steps or stages are required for this change; namely, by expanding the steam acquires velocity, this velocity being either wholly or partially utilized. After one such expansion the steam may be allowed to still further expand, again acquiring velocity, and this process may be repeated many times. The cycle of operation corresponding to each such expansion is commonly called a stage, and a turbine is spoken of as single expansion or multiple expansion, according as to whether it has one or more pressure stages. The best known and most extensively used turbine of the single stage

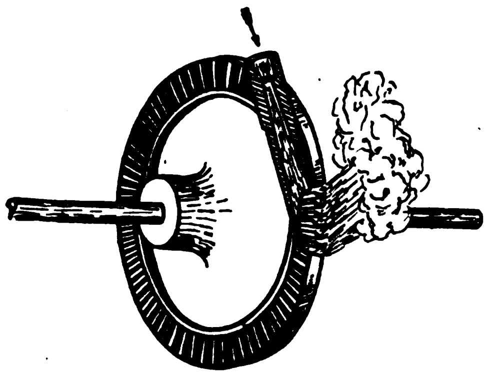


Fig. 2.

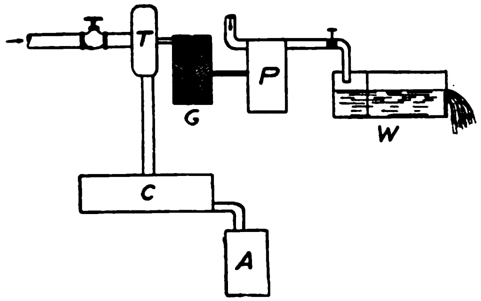
type is the De Laval. A diagrammatic view of such a turbine is shown in Fig. 2. While but one nozzle is shown in this figure, still it is common to employ several, some of the larger ones having four or five nozzles. In this turbine there are a number of turbine buckets or vanes mounted upon the periphery of a wheel. The steam is admitted to the nozzles where it expands and enters the turbine buckets with a high velocity, causing the wheel to rotate. Since in this type of turbine the wheel rotates in a chamber full of steam at exhaust pressure, there is but little resistance offered to the rotation of the moving parts. Turbines of this class are very simple, because all of the available heat energy is converted in a single step into kinetic energy. As the wheel rotates at a very high speed, it is necessary to employ a flexible shaft which can deflect enough to take care of any eccentricity of its center of gravity. If this were not done, the slightest unbalancing of the rotor would cause serious vibration. A 5 h.p. turbine revolves 30,000 times per minute, while the diameter of its wheel is about 4 in. A 30 h.p. turbine makes 20,000 revolutions per minute, with a wheel diameter of 8.9 in.; and a 100 h.p. turbine has a speed of 13,000 revolutions per minute, and a wheel diameter of 19.7 in. It is thus seen that the high speed of the turbine precludes its use for the direct driving of machinery, unless some form of reducing gear is used. Therefore it is customary to employ helical gears, which will reduce the speed 10 to 1. Gears with this speed ratio are customarily employed on all sizes of De Laval turbines. The reason for the use of this type of gears is on account of its smooth-running qualities. While the machine is speeding up, it reaches a point at about one-sixth of its rated speed at which the machine commences to vibrate. This speed is known as the critical speed. However, the flexibility of the shaft allows the wheel to choose its own axis of rotation, and after the critical speed is passed, the wheel runs with perfect smoothness, since the axis thus chosen passes through the center of mass of the wheel. It is quite easy to make the shaft spindle flexible, since the high rotary speed allows it to be made quite slender, and even on a 150 h.p. turbine, the spindle is but 1 in. in diameter.

The high speed of rotation of turbines renders them suitable for direct connection to both blowers and fans, and we find the De Laval turbine much used for these purposes.

The De Laval blades stand the impact of the high-velocity steam-jet very well, and these turbines may be run many years without replacement of blades, while, during this time, there is but little falling off in economy.

Upon first starting, after erecting, or after a long shut-down, the bearings should be flooded with oil and the nozzle valve opened about half a turn. The steam is then turned on and the governor-valve and wheel-case allowed thoroughly to heat. In order to give the bearings time to heat thoroughly, the turbine should be started gradually. If the turbine is running condensing, the condenser should be started before starting the turbine. When starting with no load, it is best to have a low vacuum of from 24 to 25 in. of mercury, and, as the load is applied, the vacuum should be raised to its maximum. As far as possible, changes in the power output of the turbine are obtained by shutting off one or more of the nozzles.

The advantages claimed for the turbine over the best of the reciprocating engines are high economy under varying loads, less weight and smaller floor space, uniform angular velocity and close speed regulation, less cost and inexpensive foundations, freedom from all vibration, adapted for highly superheated steam,




P—pump C—condenser A—tank for weighing water
W—weir T—turbine G—Gear

no need of internal lubrication, ease of erection and quickness of starting, small cost of maintenance and attendance, water of condensation free from oil and the steam economy is but little affected by wear or the lack of adjustment.

The following results were obtained as a result from tests carried on by the author.

### DESCRIPTION OF TEST

The turbine was directly connected to a pump through 10 to 1 gears, as shown in the diagram. The discharge pressure of the pump was regulated by a valve placed in the pipe near the weir. (The weir was used for the purpose of measuring the water discharged by the pump.) Three tests were run, each of twenty minutes' duration and with different discharge pressures, the necessary measurements being taken for each test. The pressure of the steam entering the turbine, the weight of water from the condenser (which was equal to the weight of steam supplied to the turbine), the vacuum of the condenser, the suction and discharge pressures of the pump, the height of water flowing over the weir, (found by means of a hook gauge), were the measurements taken.

The results obtained were the work done in horse-power, the B.t.u. per minute per horse-power of water work done, and also of turbine work done, the thermal efficiency of turbine and pump and also of turbine alone, the ideal efficiency of the turbine, the percent of ideal efficiency attained by the turbine, the capacity of the pump in gallons per minute, and the steam used per hour per horse-power of both water work and turbine work done.

### DATA—STEAM TURBINE

| | |
|---|---|
| Width of weir | .8 ft. |
| Weight of water | 62.3 lb./cu. ft. |
| Quality of steam at throttle | 99 percent |
| Diam. of discharge pipe | 4.03 in. |
| Area of discharge pipe | 12.76 in. |
| Nozzle for 150 lb. and condensing | |

### OBSERVATIONS

Barometer, 30 in., 14.74 lb./sq. in.

| Run No. | I | II | III |
|---|---|---|---|
| Boiler pressure, gauge in lb. | 141.7 | 141.7 | 141.6 |
| Steam pressure under gov. valve | 141.8 | 142.0 | 135.3 |
| Vacuum in condenser (inches) | 26.0 | 25.9 | 26.2 |
| Back pressure (lb.) | 1.97 | 2.02 | 1.87 |
| Steam used in 20 minutes (lb.) | 88.0 | 83.5 | 77.0 |
| Revolutions per minute | 29550 | 29060 | 29700 |
| **CENTRIFUGAL PUMP** | | | |
| Revolutions per minute | 2955 | 2906 | 2977 |
| Discharge pressure (lb.) | 22.6 | 29.9 | 40.0 |
| Discharge pressure (ft.) | 52.2 | 69.1 | 92.5 |
| Suction pressure (in. Hg.) | 14.0 | 12.1 | 10.0 |
| Suction pressure (ft.) | 15.9 | 13.7 | 11.3 |
| Rdg. Hook gauge (in.) | 6.25 | 5.52 | 4.44 |
| Zero rdg. hook gauge (in.) | 2.375 | 2.375 | 2.375 |
| Head of water on weir (ft.) | .322 | .262 | .172 |
| Water over weir per min. (lb.) | 1770 | 1310 | 707 |
| B.t.u. available per min. | 4810 | 4570 | 4210 |
| Pump efficiency (percent) | 44 | 50 | 44 |
| C (value from tables) | .601 | .607 | .619 |

Value of "velocity of approach" is small, so we may disregard it.

$$q=C \times \tfrac{2}{3}(b)\sqrt{2g}\,H^{3/2}$$

Run No. 1

$$q=.601 \times \tfrac{2}{3}(.8)\sqrt{64.4}(.322)^{3/2}=.472 \text{ cu. ft./sec.}$$

$$v=\frac{q}{12.76}\times 144=11.3q$$

Run No. 1 $v=11.3\times .472=5.34$ ft. per sec.

$$h=\frac{v^2}{2g}=.0155\,v^2$$

Run No. 1 $h=.441$ ft.

*Total lift=total press. hd.+vel. head*

Run No. 1 66.8+.4=67.2 ft.

*Water work done*

Run No. 1

$$\frac{62.3 \times 66.8 \times .472 \times 60}{33{,}000}=3.58 \text{ h.p.}$$

*Turbine work done*

Run No. 1 $\dfrac{3.58}{.44}=8.14$ h.p.

*Capacity in gal. per min. over weir*

$q \times 60 \times 7.48=$Cap.

Run No. 1 .472 x 449=212 gal. per min.

IDEAL EFF.

$$e=\frac{H_1-H_2}{H_1-q_2}$$

Run No. 1

$$e=\frac{1185.8-904.4}{1185.8-93.6}\times 100=25.7\%$$

Run No. 1

$p_1$=boiler pressure (abs.) 156.4
$p_2$=vacuum of condenser 1.97
$x$=99%

*B.t.u. per lb. per min.* = $H_1-q_2$

Run No. 1 1185.9—93.6=1092
$p_1$=gov. press. (abs.)

*Lbs. of steam used per min.*

Run No. 1 4.4 lbs.

*B.t.u. per min. used*

Run No. 1 4.4 x 1092=4810

*B.t.u. per h.p. of water work done (per min.)*

Run No. 1 $\frac{4810}{3.58}$=1340 B.t.u.

*B.t.u. per h.p. of turbine work done per (min.)*

Run No. 1 $\frac{4810}{8.14}$=592 B.t.u.

*Thermal eff. of turbine and pump*

Run No. 1 $\frac{42.42}{1340}$=3.16 percent

*Thermal eff. of turbine*

Run No. 1 $\frac{3.16}{.44}$=7.19 percent

*Percentage of ideal attained by turbine*

Run No. 1 $\frac{7.19}{25.7}$=28.0 percent

*Stm. per hr. per h.p. of water work done*

Run No. 1 $\frac{60\times 4.4}{3.58}$=73.8

*Stm. per hr. per h.p. of turbine work done*

Run No. 1 $\frac{60\times 4.4}{8.14}$=32.4

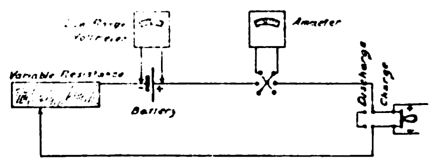
*B.t.u. available per min.*

Run No. 1 $\frac{1092\times 88.0}{20}$=4810

RESULTS

| | I | II | III |
|---|---|---|---|
| Total lift (total press. hd.+hd. due to vel | 67.2 | 80.5 | 103.4 |
| Work done in h.p. | 3.58 | 3.18 | 2.21 |
| B.t.u. per min. per h.p. water work done | 1340 | 1440 | 1900 |
| B.t.u. per min. per h.p. turbine work done | 592 | 720 | 835 |
| (assuming eff. of pump under head of— | 66.8 | 80.3 | 103.3 |
| Percent as— | 44 | 50 | 44 |
| Percent of thermal eff. of turbine and pump | 3.16 | 2.94 | 2.23 |
| Percent of thermal eff. of turbine alone.. | 7.19 | 5.88 | 5.07 |
| Percent of ideal eff. of turbine | 25.7 | 25.6 | 25.9 |
| Percent of ideal eff. attained by turbine. | 28.0 | 23.0 | 19.5 |
| Capacity in gal. per min. | 212 | 157 | 84.8 |
| Steam per hr. per h.p. work done (water) | 73.8 | 79.0 | 104.5 |
| Stm. per hr. per h.p. work done (turbine) | 32.4 | 39.4 | 45.9 |

In Mr. A. Sprung's article on page 36 of the January issue, reference is made to the necessary connections used in finding the commercial efficiency and characteristic curves of a lead storage battery




by means of an experimental solution. The cut showing these connections was omitted from the body of the article and is given here.

Common garden hose attached to an independent condenser in the power station, is a fine extractor of dirt from the inside of an armature or other electrical apparatus, where it is undesirable to raise dust. The hose should be void of any metallic substance on the end applied to the armature. The most desirable time to apply this cleaner is when the engines are off.

# PULLEYS—Part II

### USE OF GUIDE PULLEYS

There is no essential difference between a guide pulley and one used for transmitting power, except that its strength

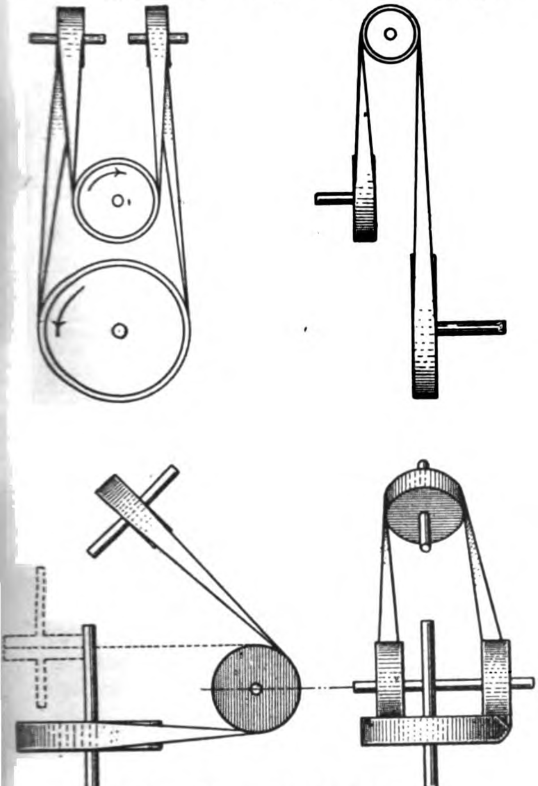


Fig. 11. Common Use of Guide Pulley

need not be so great and that it runs loosely upon the shaft. Guide pulleys are used to direct a belt to the proper place on the main pulleys in drives that are so complicated that direct means will not suffice. Illustrations of their varied uses are shown in Figs. 11 to 16. The arrangement of two shafts so close together that a direct belt cannot be used is shown in Figs. 11, where it is necessary to employ two guide pulleys, which are placed upon the same arbor or may be separated with axes at an angle with each other.

It sometimes occurs that pulleys cannot be placed in the same plane upon parallel shafts, but must be offset, as shown in Fig. 12, and in this case guide pulleys must be employed, these being placed upon the same arbor and run in the same direction, the diameter of the guide pulley in this case being equal to the offset of the main pulleys.

The arrangement of two shafts in the same plane but at an angle with each other is shown in Fig. 13. In this case also, two guide pulleys are necessary to secure best operation of the belts. A solution of the quarter turn arrangement is that shown in Fig. 14, where one guide pulley is used. The quarter turn arrangement is frequently bothersome and the use of a guide pulley is advisable in a great many cases. Another solution of the same problem is shown in Fig. 15, where two guide pulleys are employed.

It frequently occurs that by use of a guide pulley which is adjustable in its position, the belt can be shifted from the loose to the tight pulley, as shown in Fig. 16, without the use of a belt shifter.

### BELT TIGHTENERS

To secure the best operation and highest economy from belts it is essential that a constant, uniform tension be employed while the belt is running. Owing to the stretch and shrinkage of belts due to long use or changing conditions of the atmosphere, it frequently becomes necessary to employ some means of taking up the slack which is thus caused. This

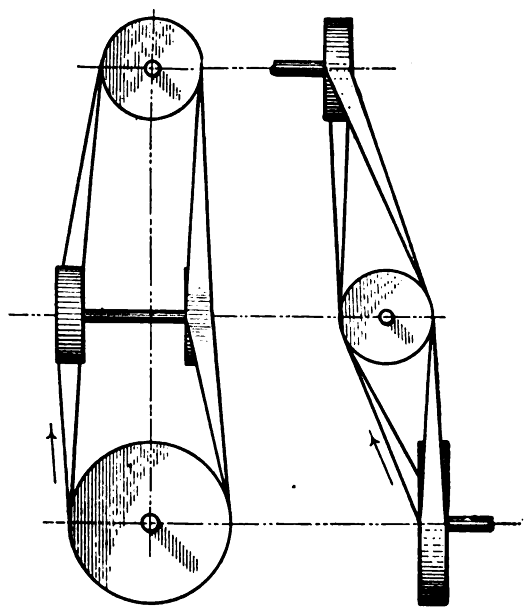


Fig. 12. Pulleys Offset

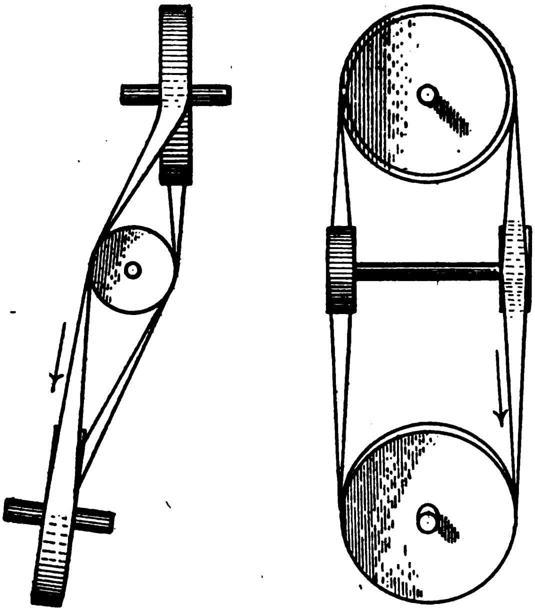


Fig. 13. Transmission between Shafts at an Angle

is particularly the case where belts run between line shafts, or between the engine shaft and a line shaft. It is seldom necessary to employ a belt tightener between the line shaft and a motor or other small apparatus, inasmuch as these pieces of machinery are usually provided with means for shifting the entire machine upon its bed, thus taking up any slack or relieving an undue tension upon the belts.

As a general rule the belt tightener consists of a loose belt pulley running upon a shaft parallel to the shaft upon which the succeeding pulley is placed. This pulley is arranged so that it can be shifted at right angles to its shaft and held in any desired position, either by springs, weights or screws, according to the size and power transmitted by the belt.

For small belts the tightener is usually placed upon an arm and presses against the loose side of the belt a short distance from the smaller pulley, thus giving the pulley the advantage of a longer arc of contact with the belt. In this case the tightener is usually held in position by a weight or spring of proper size, thus keeping the belt at the proper tension automatically.

For heavy duty, a large belt tightener is employed, and the tension is regulated by means of a hand wheel and screw, thus making it possible to obtain any desired belt tension. In many cases of this kind the belt tightener is employed for no other purpose than to give greater arc of belt contact on the pulleys.

Another use for belt tighteners is on vertical belts where, by increasing the tension, the upper shaft is put into service; and by decreasing it the belt will hang loose around the driving wheel, thus stopping the upper shaft. This use, however, is not recommended as good practice, for the reason that the driven shaft cannot be stopped instantly, and the belt hanging loose upon the driving pulley is subject to considerable wear at the point where it happens to come in contact with the wheel, and is liable to cause accidents by slipping to one side of the driver and catching on a key or set screw.

In design, belt tightener pulleys are similar to other belt pulleys, but where they run loose upon a shaft the hub is lined with bearing metal or otherwise highly polished. The pulley is also provided with some kind of lubricating arrangement, and should be kept thor-

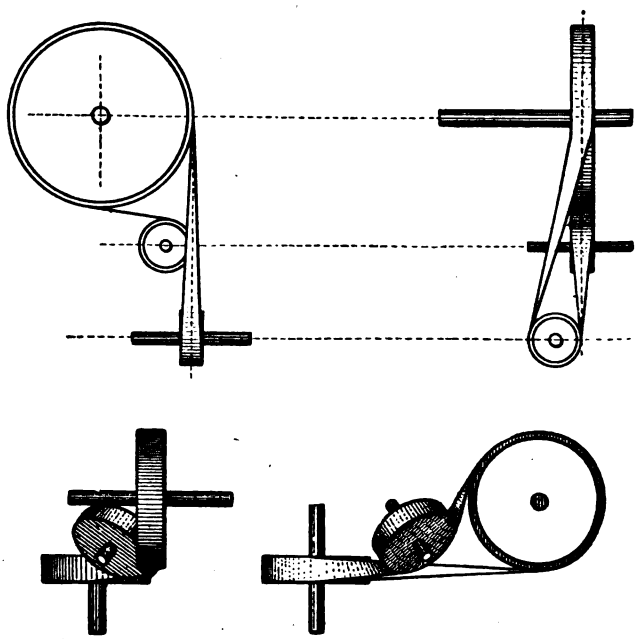


Fig. 14. Quarter Turn Arrangements Using One Guide Pulley

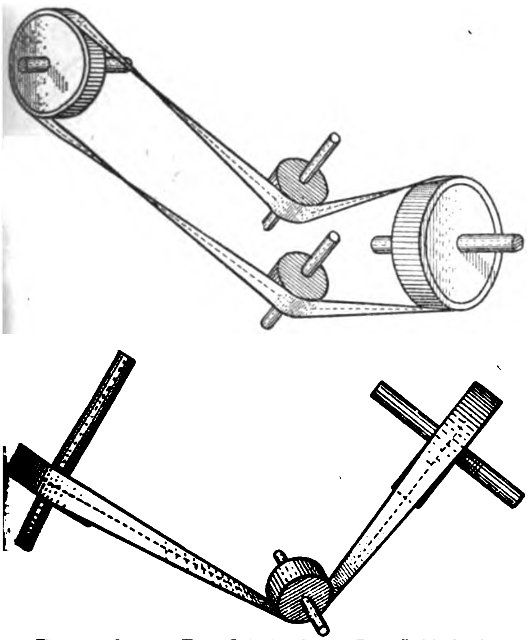


Fig. 15. Quarter Turn Solution Using Two Guide Pulleys

oughly lubricated if expected to operate to best advantage.

### FAST AND LOOSE PULLEYS

It is only in a few cases that several pieces of machinery operated from the same line shaft are all working at the same time, and in order to stop one machine while the others are still working it is necessary to provide some means by which the driving belt may be stopped without stopping the line shaft. One of the most common and satisfactory means is to provide a fast and a loose pulley upon the line shaft for each piece of apparatus, so that when a machine is to be operated the belt is shifted to the fast pulley, and when it is desired to stop the machine the belt is shifted back to the loose pulley, which is placed upon the shaft directly beside the tight or driving pulley.

The follower or pulley upon the machine is of double width, thus allowing the belt to run from one side to the other as the machine is working or idle. Aside from the fact that the driven pulley is of double width for the belt and has a flat face, its design is usually similar to standard pulleys. The driving pulley and the loose pulley placed upon the line shaft beside it are of standard design, except the width of the pulley face is not so great as that of an isolated pulley, thus making it easily shifted from one to the other. It is always best, where possible, to place the tight and loose pulleys upon the line shaft and the double width pulley upon the machine, by this arrangement, when the machine is not in operation the belt is not running, and its life will therefore be lengthened considerably. It frequently occurs, however, that the machine requires considerable power to start it, and it would be a difficult matter to shift the belt from one side of the pulley to the other without having it in motion. In such cases it is necessary to place the tight and loose pulleys upon the machine itself, and the belt must therefore be in operation all the time.

Another arrangement frequently resorted to is that of reversing a machine by means of shifting belts. In this case, however, it is necessary to employ two belts, one of which is open and the other crossed. The arrangement also requires the employment of one tight and two loose pulleys, thus having the loose pulleys on the outside with the tight pulley at the center, the follower pulley having a width a little more than three times the width of the belt. Where a machine is periodically reversed an automatic belt shifting arrangement is employed, thus relieving the operator of this responsibility.

Tight and loose pulleys are also frequently employed where a quick return movement of the machine, such as a planer, is desired, by providing two sets of tight and loose pulleys and belts, the ratios between driver and follower being

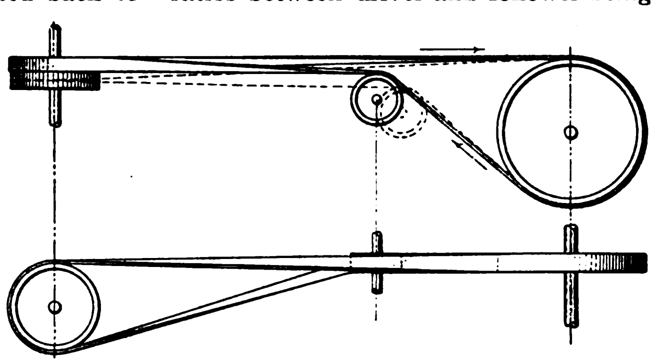


Fig. 16. Guide Pulley Used as Belt Shifter

chosen to give the desired speed of the machine.

BELT SHIFTERS

The most common form of belt shifter consists of two parallel fingers placed one on either side of the belt with the space between a fraction of an inch greater than the width of the belt, these fingers being attached to a rod parallel to the shaft upon which the following pulley is placed. This rod is movable endwise the distance the belt has to be shifted and is always placed on the advancing side near the set of tight and loose pulleys. The shifter is operated by a lever or system of levers most convenient to the operator.

As stated above the shifters may be worked automatically, where the machine is to be run alternately in opposite directions or for a quick return motion which takes place periodically. This is usually done by means of a lever and weight upon the machine, which is operated by the machine until it gets into a vertical position when it drops over to the other side, thus shifting the belt while the machine is coming to rest and starting up in the opposite direction.

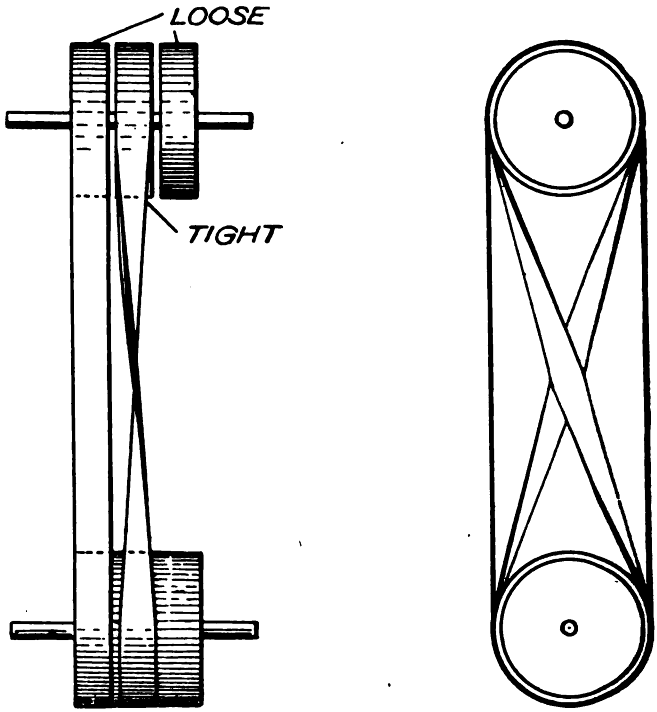


Fig. 17. Belt Arrangement for Reversing

LOCATION OF PULLEYS

To secure the best service from the belt and pulleys and take advantage of the slack in the belt to give a greater arc of contact on the pulleys, they should be placed with their shafts parallel and in the same horizontal plane and the tight side of the belt at the bottom. This, however, is not always possible, and it is found necessary to run the belt at an angle from the horizontal, but vertical belts should never be employed where it is possible to run them otherwise. The difficulty here is that a belt must always have a belt tightener upon it, as any slack which shows up in the belt causes the lower pulley to slip in the belt. To the difficulty arising from high tension of vertical belts may be added the trouble with an over pressure on the upper shaft bearings and the lifting of the lower shaft in such a way as to wear on the upper part of the bearings. These conditions

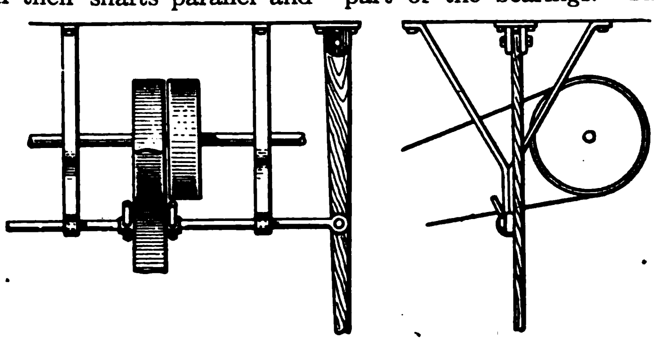


Fig. 18. Belt Shifter

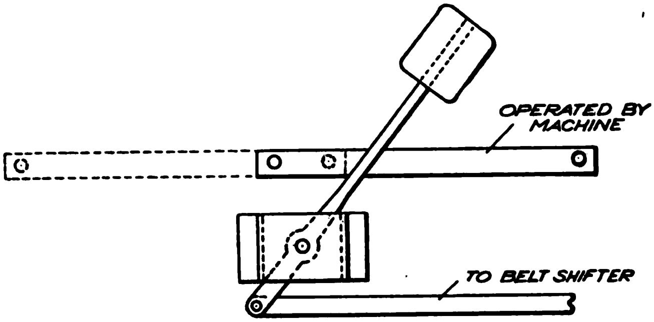



Fig. 19. Automatic Belt Shifter Device

are unnatural and should be avoided whenever possible.

A driven pulley located upon a long line shaft which has placed upon it several driving pulleys should be located as near to the center of the load as possible. In this way it will be seen that the diameter of the shaft can be reduced considerably, as only half the power of the whole shaft is transmitted in each direction, and also the vibration, which is likely to occur in long shafts.

## IMPROVED LECLANCHE CELLS

Mr. J. G. Lucas, of the headquarters' staff of the British Post Office, read a paper the other day, dealing with the result of some investigations which had been carried out in practice and under laboratory conditions in connection with the ordinary types of signaling batteries used by the British Post Office and other telephone administrations. Dealing with the porous pot Leclanché type of cell, the author showed that the text-books were very much out of date on this question and that modern telephone requirements could be met much more economically by modifying the subdivision of the manganese dioxide and carbon in the porous pots. In the case of even such small current discharge rates as 40 milliamperes the result of the modifications was to decrease the total working costs not less than seven-fold, while at discharge rates higher than 40 milliamperes the decrease in costs was much greater. The agglomerate form of Leclanché battery was an expensive type, and the possible advantages which might be derived from its use were not commensurate with this expense. In connection with the use of dry cells as at present designed, the investigations went to show that the chief difficulties and expense lay in the fact that for discharges which must necessarily be spread over several months full use could not be made of the chemical energy contained in the materials used in these cells owing to the sudden rise, after a time, in the internal resistance. Details were given of experimental cells, the behavior of which indicated that the difficulties were not insuperable. The free ammonia gas evolved from Leclanché cells being found to affect seriously the metal work of telephones and to act deleteriously upon secondary cells, details were given of satisfactory experiments which had been conducted with an electrolyte of manganese chloride instead of the usual ammonium chloride solution. The author pointed out the practicability of sealing up the battery compartments in connection with cells charged with manganese chloride solutions and the consequent reduction in loss by evaporation as compared with ammonium chloride.

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A first-aid fire engine which derives its propulsive energy from electric accumulators has been brought out in England. The cells are of sufficient capacity to enable the vehicle to travel for 24 miles. The current is supplied to two independent motors, each driving one of the rear wheels by means of a silent chain and a worm wheel reduction gear enclosed in an oil-tight case and running on ball-bearings. The vehicle will travel at 20 miles an hour, and will ascend a ten percent gradient. Accommodation is provided for six to eight men, for a 30 gal. water cylinder, which is kept under pressure by a cylinder of carbonic acid gas, and for 1,000 ft. of canvas hose, 30 ft. telescopic ladder, standpipes, etc.

## THE LIGHTHOUSE SERVICE

Acts of heroism and instances of casualties in the line of duty among the faithful army of men—and women, too, for the late Ida Lewis, "America's Grace Darling," was one of them—who keep the government lights and beacons burning along the shores of the oceans, lakes, and larger rivers, are cited in the report for the fiscal year ended June 30 last, which Commissioner George R. Putnam, of the Bureau of Lighthouses, has submitted to Secretary Nagel, of the Department of Commerce and Labor.

These show the hazardous nature of the daily duties of fully three-fourths of the 5,500 present employees of the service, which is more extensive than any other lighthouse organization in the world. Notwithstanding this continual imperiling of limb and life, the average annual salary of a lighthouse keeper is but $600, although some of them earn more, while others make considerably less. These sturdy, brave and loyal guardians of navigation are drawn generally from among the hardy people who have been brought up by the sea and have taken up this dangerous work as it seems to appeal to them specially.

### THE AGED AND THE DISABLED MUST BE DISCHARGED

Notwithstanding the small pay given, as the letter of the present law stands, those who are unable to perform their duties must be discharged. It does not matter whether the employee, advancing in years, is racked and twisted with rheumatism from exposure to the furious gales of summer and winter, or whether he, still in the prime of youth, is incurably crippled from a daring rescue of human lives from the waters of the sea.

### THE REORGANIZATION OF THE SERVICE

The act of Congress of June 17, 1910, providing for a more direct administration of the service by placing it under a simple bureau form of organization, in the Department of Commerce and Labor, went into effect July 1, 1910, and the report, therefore, covers the first year of the new arrangement.

There has been, as a consequence of the reorganization, a saving in personnel, amounting to about 200 positions; in rents of offices and docks, and particularly in the use of lighthouse tenders; and yet the service has been steadily extended.

In carrying out the changes in the personnel an effort was made to avoid causing hardship to persons long in the service. When it was necessary to reduce the number of positions in any district the employees so discontinued were transferred to other places in the service, or, when practicable, to other branches of the government. To promote the efficiency of the service in general and to secure the best results in technical lines of work, a plan has been formed to have young men with suitable preliminary technical education enter the lower grades to be trained for the higher positions. In pursuance of this plan steps have been taken for the appointment of aids, cadet officers and cadet engineers.

Commissioner Putnam earnestly states, therefore, that there is great need for provision by law for the retirement of employees who, after long service, have lost their ability for active duty by reason of age or disability incident to their work. He considers it is not only a matter of humanity, but a business proposition, and in the best interests of the service. In England the lighthouse organization has a retirement system in the form of a life assurance policy. After three years of service each employee is given one, and in case of disability or superannuation the proceeds of it provide a means of maintenance for life. Germany, France, Denmark, Holland, Norway and Sweden have straight pension funds.

Provision should be made, the commissioner adds, for compensation to persons injured while engaged in hazardous employment in the Lighthouse Service, by extending to them the benefits of the act of May 30, 1908, "granting to certain employees of the United States the right to receive from it compensation for injuries sustained in the course of their employment." The only persons in the service now entitled to the benefits of this law are the artisans or laborers employed at the General Lighthouse Depot at Tompkinsville, N.Y., which has been construed to be a "manufacturing plant" under the terms of this act. Much of the work of the service is of a hazardous nature, such as the construction and repair of lighthouses and beacons, sometimes in very difficult locations, the handling of gas buoys and gas tanks, and of other heavy weights on vessels. It is believed that there is no class of government employees more justly entitled to consideration in case of injury while engaged on hazardous duty.

### THE PAST YEAR'S WORK

The Lighthouse Service is charged with the lighting and maintenance of lighthouses, light vessels, buoys and other aids to navigation, along all the coasts and the principal interior rivers under the jurisdiction of the United States, with the exception of the Philippine Islands and Panama. There are 19 lighthouse districts, each in charge of an inspector. During the year three new districts were created, one including Alaska, one Porto Rico, and the third the Hawaiian Islands.

The service maintains at the present time over 12,000 aids to navigation, including lighthouses, light vessels, buoys, beacons and fog signals. During the year, 693 aids were established and 218 discontinued, leaving a net increase of 475. The service has 63 light vessels on 51 stations, the vessels in excess being used for relief. Some important improvements in the types of illuminating apparatus have been introduced on the light vessels.

There are at present 46 lighthouse tenders stationed along the coast, and used to supply light stations and vessels and for inspection and construction of new works. During the year five tenders were sold or transferred, being not worth repair for lighthouse purposes and not needed under the reorganization. One new tender and one new light vessel have been completed, and plans are under way for additional vessels to take the place of others as they become worn out.

The business methods of the service have been examined and various modifications made; a cost-keeping system introduced; and a general lighthouse inspector and an examiner, or traveling auditor, have been appointed to go systematically from district to district and examine both technical and business methods, the maintenance of vessels, etc.

Improvements in lights and other aids to navigation have been made as rapidly as means would permit. Two hundred and ninety-six lighted aids to navigation have been established during the year, including first-class stations at Cape Hinchinbrook, Alaska, and White Shoal, Rock of Ages and Split Rock, on Lakes Michigan and Superior. Twelve lights have been changed from fixed to flashing or occulting lights, giving a more distinctive characteristic. Incandescent oil-vapor lamps have been introduced in place of oil wick lamps at 29 stations, giving a much greater brilliancy of illumination for the amount of oil used. Acetylene lights have been installed in place of oil lights at 16 stations. These are mostly unattended lights, not requiring the services of light keepers. The marking and lighting of the new Livingstone Channel of the Detroit River is in progress, as this important channel will probably be open for navigation next year.

### PROGRESS IN ALASKA

The need of additional aids to navigation in Alaska has been recognized. It was made a separate district and an inspector placed in charge with an office and depot at Ketchikan and Tonka. Two lighthouse tenders have been at work. There have been established 37 new lights, 2 unlighted beacons, 22 buoys, and 1 fog signal. A year ago there were 37 lights in Alaska, so that the number has been doubled since. Preliminary arrangements have been made for the installation of 27 additional lights during the current fiscal year, and an estimate is submitted for the establishment of a first-class light and fog signal station at Cape St. Elias. There are now 236 aids to navigation in Alaska, of which 74 are lights.

### NEW TYPES OF LAMPS AND SIGNALS

Investigations and experiments have been continued throughout the year for the improvement of apparatus used in the service. A new type of oil-vapor lamp has been developed and put into use at various stations. The use of acetylene gas has been extended, especially for unwatched beacons and buoys, including large lighted buoys at sea, which will operate for long periods without attention. This gas has also been used for many of the unattended beacons in Alaska, where it is difficult to provide light keepers. Steps have been taken for the improvement of fog signals, particularly with a view to having them sounded instantly on the approach of fog. Investigation is being made of the availability of wireless telegraphy for fog signals.

The appropriations for the general maintenance of the service for the present fiscal year were $433,000 less than for the preceding year, this reduction being due largely to economies effected in the reorganization. The use of the appropriations of $290,000 for the construction of three lighthouse tenders was also deferred, as these vessels were not immediately needed.

The estimates submitted for the maintenance of the Lighthouse Service for the next fiscal year are practically the same as the appropriations for the present year. These estimates include new vessels required to replace light vessels and tenders as they become worn out in service, and important new lighthouses and depots for the conduct of the work of the service along all portions of the coasts of the United States and outlying territories.

## A New Aeroplane Engine

The Yorkshire *Observer*, in an account of a lecture delivered before the Leeds University Engineering Society by R. J. Isaacson, gives his claims as the inventor of an improved aeroplane engine, as follows:

"He stated that it (his new engine) was based on the same general principles as the Gnome, but embodied many of his own devices, notably one which enabled the engine to be started slowly and run at almost any speed up to its maximum that the aviator wished. This was a vast improvement, because with all machines in use at present, it was only possible to work at one speed, and that the highest. Therefore, where an aviator, having attained a considerable height, wished to descend, he must shut his engine off altogether. But if the propeller once stopped revolving it was impossible to re-start the engine without help, and therein lay the reason for the awe-inspiring vol-planers, by which aviators descended from great heights. It was necessary to descend at great speed, so that the force of the air against the propeller might keep it in motion in order that when the aviator neared the ground he might re-start his engine, and thus control his movements. Mr. Isaacson claimed that the use of his engine would obviate all necessity for vol-planing."

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*The Man at the Door:* "Madam, I'm the piano-tuner."

*The Woman:* "I didn't send for a piano-tuner."

*The Man:* "I know it, lady; the neighbors did."—*Chicago News*.

## Calorized Electric Soldering Iron

The use of the ordinary soldering iron has two serious drawbacks: the impossibility of keeping it hot continuously, and the rapid wasting away of the copper. The development of the electric soldering iron obviated the former, furnishing the mechanic with an iron which not only stayed uniformly hot all the time, but one in which the heat intensity could be easily regulated by the mere turning on or off of the current. The second fault, that is, the rapid wasting away of the copper, still remained, to a large extent, necessitating frequent renewals, and consequently making no reduction in the cost of maintenance.

Therefore it is of much interest to metal workers to know that many experiments made in the research laboratories of the General Electric Company to mitigate this fault has resulted in the discovery of a process of treating the copper which renders the latter non-oxidizable under high heats and non-corrodable by the acids used in soldering. Furthermore, it reduces to a minimum the dissolving action of the molten tin, with which the working tip must always be kept coated.

This "calorizing" process or method of treatment does not merely coat the surface of the copper with a thin layer of non-oxidizable or non-corrodable substance, liable to scale off under the effects of heat and acids, but actually changes the characteristics of the copper to an appreciable depth. Thus the durability or practical working life of the copper is increased to such an extent as to provide a soldering iron of maximum economy and effectiveness.

## SETTING DRILLS CENTRAL WITH SHAFTS

When holes have to be drilled transversely through shafts and spindles, some rapid and accurate means of setting the shaft truly in relation to the drill is desirable. Sometimes the centering is automatically effected, because the vee block or blocks that receive the shaft are guided by a slot in the machine table, or in the poppet drilling-plate in the case of a lathe, or a solid vee block is used with a taper shank to fit the poppet barrel. But if none of these conditions are present, the drill must be adjusted with the help of some kind of device, of which we offer three as suggestions.

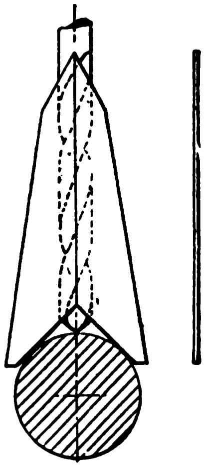

Fig. 1.

Fig. 1 is a center gauge, with a vee recess at one end and a point at the other. When set upon the shaft, as shown, the point should come into the center of the drill if the latter is standing correctly. This dodge is also useful for hand-drilling, with brace or hand drill.

Another method is to elaborate the gauge into a block, with two vee grooves at right angles (Fig. 2), one resting on the shaft, the other against the drill. The shaft is slid about until the contact is correct.

Perhaps an easier block to use is that illustrated in Fig. 3, in which the drill fits into a hole, thus controlling the block rigidly while the shaft is being adjusted. Either three holes, as shown, or a greater number, may be made in the block.—*Model Engineer and Electrician.*

Setting Drills Central with Shafts.

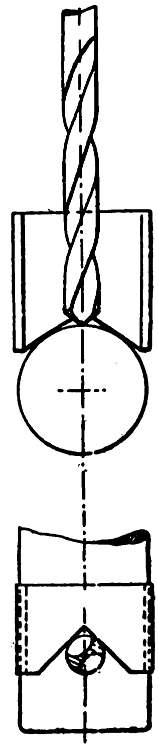

Fig. 2.

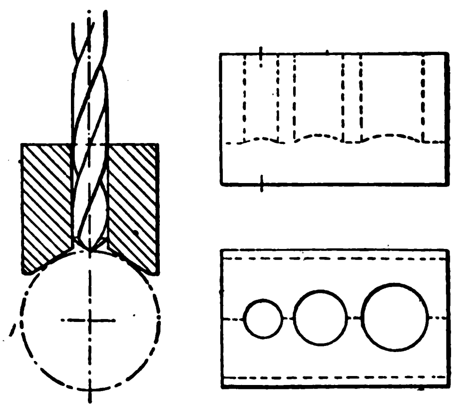

Fig. 3.

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A man was trying to call a party over the telephone. The two girl operators were discussing clothes and what they should wear, when the man interrupted. The girl was angry, and asked: "What line do you think you are on, anyway?" He said, "Well, it seems as if I am on a clothes-line."

## STEEL PEN MAKING

### Study of the Processes from the Rough Sheet to the Finished Pen, Packed Ready to Use

In excavating the ruins of Pompeii the earliest specimens of metallic pens were found. These were of bronze. Most of the early metallic pens were of this metal, although some were made of silver. The forms of the first steel pens were copies of the quill pen, being both pen and holder combined. They were slit like the quill pen.

#### EARLIEST FORM OF STEEL PEN

This style of pen was used for a number of years, but was very expensive, because as soon as the pen was worn out it was necessary to throw away practically both the holder and the pen; so the nib part was made separate, and the barrel part became the tip of the penholder of today. This was a great economy; and soon the pen took its present form, and the penholder was made to hold it.

One of the objections to the early steel pens was their stiffness. This was overcome by the introduction of the side slits; by varying the size, shape and position of these side slits a pen can be given any resiliency desired.

The steel pen industry did not make any rapid advances until the adoption of the foot, drop and screw presses, about the year 1825; then they were manufactured in fair quantities, but their introduction was by no means rapid, for even as late as 1860 to 1865 the Quartermasters' Department furnished the United States army with the quill pens. The first steel pens sold anywhere from 35 to 50 cents each, so that one pen cost as much as will now buy from one-third to one-half a gross of the better grades. In other words, they cost from 50 to 75 times as much as they do now. The consumption has increased very rapidly, and at the present time the world probably produces from ten to twelve million gross annually, of which the United States produces 2,500,000 gross and consumes over 3,000,000 gross.

#### PROCESSES OF MANUFACTURE

Although the pen may be mightier than the sword, its daily use by millions of people has made them insensible to its importance, and those who have given it a thought believe that the sheet steel goes in one end of a machine and the completed pen falls from the other end. This is far from being the case, as there are from 20 to 28 handlings, the number depending on the style of the pen.

The steel is imported from England and consists of selected sheets, 19 in. wide, about 5 ft. long and .023 of an inch thick. It is of the very highest grade—American manufacturers not having attempted to make this class of steel.

The first operation is to cut the sheets into strips 19 in. long and wide enough to cut two pens with their points interlapping. These strips, which are rolled hard and are too thick to cut a pen from, are annealed by packing them in iron boxes and heating them at a low red heat for a number of hours. They are then gradually cooled under a hood, to prevent drafts striking them. When cool the strips are soft and coated with a scale, which is removed by a pickle of dilute sulphuric acid. They are now ready to be put through the rolling mill and reduced to the required thickness, which averages about .009 of an inch.

#### ROLLING OUT THE STEEL

The rolling is known as "cold rolling," the strips not being heated after the first annealing. This gives an increased toughness to the steel. The number of times necessary to put it through the rolls depends on how thin the steel is to be rolled. Each strip is tested with a micrometer gauge, and should it be too thick it is again put through the mills, and if too thin it is laid aside for a pen for which a thinner steel can be used. The steel which started 19 in. long has been stretched to about 50 in., and is then ready for the pens to be cut from it.

Cheap pens are cut from steel that comes in large rolls ready for use. As it is impossible to roll this uniformly, the pens that are made from it are very irregular.

Pens are cut in screw presses provided with dies of the desired shape. About 200 styles of dies are required for regular and imprint pens.

An operator can cut from 40,000 to 45,000 pens in a day of eight hours, and her hand will move about seven miles in doing it.

The blanks are now pierced and side cut. These operations, to a large extent, determine the flexibility of the pen, and vary with the style of pen, some pens requiring two and three handlings in the piercing department.

### SOFTENING THE BLANKS

The blanks having been cut from hard rolled steel, it is now necessary to soften them by annealing. This is done by putting them in large iron pots, heating them to redness for several hours, and then cooling gradually. They are then soft and pliable and ready to receive the name, which is the next operation, called marking. Some pens have a raised letter or design on them, called embossing. This is done in a marking press.

After marking the pen is raised; that is, brought to the form that it is to have when finished. There are on the market about 2,000 styles of pens. Raising is done in a peculiarly constructed screw press, and the pens are removed by compressed air.

Each pen is now carefully examined for imperfections in the previous operations, and, as they are soft, it is necessary to harden them by heating them red hot and dropping into cold oil. The oil is removed by centrifugal force and boiling lye, and the pens are then dried in sawdust. This makes the pen very brittle, so that it has no resiliency. In order to obtain the latter quality, the pen is tempered by gradually re-heating it until it has acquired the greatest toughness and elasticity possible.

The pen now has a coating of oxide which must be removed by scouring. This is done by placing the pens and a scouring material in tumbling barrels and revolving them until they are bright. Girls then grind the pens on emery bobs lengthwise and across the nibs. Some pens have only one operation in this department, while others have two and three. Pens are ground to enable them to hold ink better, and also give them more resiliency.

### PROCESS OF SLITTING

The pens are now ready for slitting. As it is necessary to cut through the hardened and tempered steel without damaging the point, it can be readily appreciated that the tool for doing it must be one of the most delicate. It is a miniature shearing machine, with knives of extreme hardness, of absolutely perfect gauge to hold the pen, so that the shears will always cut through the center of the point.

After the pens have been slit they can be used for writing, but they would be very scratchy and would stick in the paper. In order to overcome this, the points are rounded and made perfectly smooth.

The final examination is now given each pen; expert examiners sit before a slanting desk, on which is a slate of black glass; the pens lie on the desk and the examiners pick up one in each hand, pressing them on the glass and looking at the cutting, piercing, marking, raising, grinding, slitting, tempering, etc. Should the pens have any imperfections in any of these operations they are thrown into separate boxes, so that each room can be charged with the amount of its waste. This waste is then put in iron pots and heated, so as to prevent their being used when they are sold for scrap steel. There are 1,728 chances to make a bad pen in every gross, consequently its manufacture requires vigilant care and inspection.

### THE FINISHED ARTICLE

The pens are now polished, and if they are to be left gray, are ready for the lacquering operation; if they are to be made bronze, blue, black or any of the various shades, they are sent to the tempering room and gradually reheated in a revolving cylinder until the required color appears upon them, when they are chilled quickly so as to prevent the color changing. The pen is now practically finished, but if put on the market in this form would rust very quickly. Each one is therefore given a thorough coat of lacquer, which preserves it. If the pens are to be plated with bronze, silver or gold, these operations are performed while the pen retains its bright polish.

The pens are counted by weight. It will be found impossible to put a gross of pens in the box intended for them unless they are laid parallel. They are put in a half cylinder and shaken. This quickly places them in a parallel position, and by a very quick move of the operative they are dumped into the boxes, which are then labeled and packed.

The typewriter has, instead of injuring, benefited the steel pen business. It has done this by increasing the volume of correspondence a hundred-fold, and thus calling forth return letters that otherwise would never have been written.—*The American Stationer*.

# FINDING THE DECIMAL POINT

## Keeping Track of this Elusive Dot when Figuring with Pencil or Slide Rule

In making computations which involve the use of decimals, there is frequently some confusion in finding where the decimal point belongs. The danger of misplacing it is illustrated by the old story of the bridge designer whose bridge fell down when about three-quarters finished, and who, on seeking the cause, went carefully over his computations and finally exclaimed: "Confound that decimal point!" In the course of figuring he had misplaced it, and the bridge was only one-tenth as strong as he had intended, which brought a breaking strain on an important member of the structure.

### FOR MULTIPLICATION

In many computations, says *Practical Engineer*, the reasonable value of the result will tell whether the decimal point is rightly placed or not; but in others where sizes are unfamiliar, we must rely on the accuracy of the figures for the correctness of the result. In the case of multiplication, while it needs some care to be sure that the decimal places are counted accurately, the rule is simple enough, namely to "point off as many places in the product as the sum of the places in multiplier and the number multiplied." For instance, in figuring the volume of 1.3148 lbs. of steam at

```
     0.02641
     1.3148
     -------
      21128
     10564
     2641
   7923
  2641
 -----------
 .034723868
```

FIG 1

```
        0.002548
    785|2.0000
        1570
        ----
         4300
         3925
         ----
          3750
          3140
          ----
           6100
           6280
```

FIG 2

```
           0.003097
    177.6|5.500000
          5328
          ----
           17200
           15984
           -----
            12160
            12432
```

FIG 3

10 lbs. absolute pressure, we find that the volume of 1 lb., as given in the steam tables, is, from the November data sheet, 0.02641 cu. ft. The operation of multiplying is then as shown in Fig. 1, and counting the decimal places in the number and the multiplier, we find that there are 9 altogether, which means 9 decimal places in the result, giving us one cipher in front of the 3 and then the decimal point.

### FOR DIVISION

In the case of division, the proper placing of the decimal point is not so easily expressed by rule, and a little kink in mechanical performances of the operation is helpful. Take the case of 2 to be divided by 785. If we set down the 2 and then the 785 to the left of it, divided by a line, as in the usual manner, and above the 2 draw a horizontal line, we may then add as many ciphers after the decimal point at the right of the 2 as needed for our purpose, and above the 2 we put a cipher, because our divisor is contained in 2, zero times. We then place a decimal point above the decimal point in the dividend and proceed with another cipher, because the 785 is contained zero times in 20, zero times in 200, and 2 times in 2,000. The method is shown in Fig. 2.

In the case where a number containing a decimal is to be divided by another one containing a decimal, there is an additional step. If it be required to find the number of pounds of steam at 26 in. vacuum, which will be contained in 5.5 cu. ft., we find from the data sheet, November tables, that 1 lb. occupies 177.6 cu. ft. To find the pounds in 5.5 cu. ft., we must, therefore, divide 5.5 by 177.6.

As before, we put down the 5.5, then draw a vertical line to the left and put down the divisor; we add zeros to the dividend as may be required, and then move decimal points in both divisor and dividend to the right until the divisor becomes a whole number, putting a cross in the former position of the decimal point to show where it was originally located. We then proceed as before, putting the decimal point in the quotient above the new decimal point in the dividend. The continuation of the calculation is shown in Fig. 3.

### FOR COMBINED OPERATIONS

These methods cover all cases for single multiplication and division, and for operations that are carried on in series, that is, one after the other. There are, however, certain calculations which are made from formulas or equations in which we have indicated a series of multiplications and divisions, and where cancellation of factors is used. Take the case of the familiar horse-power formula represented by $\frac{PLAN}{3,3000}$, in which $P$ is the mean effective pressure in a steam engine cylinder, $L$ the length of the stroke in feet, $A$ the area of the piston in square inches, and $N$ the number of working strokes per minute; a considerable amount of arithmetical work can frequently be saved by indicating the entire series of multiplications and divisions, and then crossing out factors which are common to numerator and denominator.

Assume that the mean effective pressure is 25 lbs., the length of stroke 4 ft., diameter of piston 24 in., and revolutions per minute, 75. We then have all the factors of the horse-power formula, except the area of the piston which is found by squaring the diameter, multiplying by 3.1416, and dividing by 4. Substituting the values then in the formula, we get the expression as shown in Fig. 4, the number of working strokes being equal to the revolutions per minute when only one end of the cylinder is considered.

Now, canceling out like factors in numerator and denominator, we have both 4's out, the factor 25 will cancel into 33,000, leaving 1,320, the factor 4 will cancel into 24 leaving 6, and into 1,320 leaving 335, and the factor 5 into 75, leaving 15, and into 335 leaving 67. We can readily multiply 24 by 6 mentally, giving 124, and then to multiply by 15 we have 10 times 124 is 1,240, and half that will be 5 times 124 or 620, and the sum of the two gives 1,860. Then by long multiplication we take the product of 3.1416 and 1,860, giving, with 4 places pointed off, 5,843.3760. Performing the division and locating the decimal point by the method already given we get 87.21 as the horse-power.

The experienced engineer will know from the dimensions and data given, whether this is about right for the horse-power or not, but for the novice there might be a delightful state of uncertainty whether it ought to be 87 or 872 h.p., as the loss of the cipher anywhere in the cancellation would throw the position of the decimal point out of its proper place. It is useful, therefore, to make a rough check to prove the decimal point's position, as shown at the bottom of Fig. 4.

Fill out the formula, raising or lowering values to bring them to the nearest figure having a zero or a 5 as the last digit, and taking care to raise about as many factors as are lowered. In this way an expression will be secured which can be quickly canceled to a few simple factors that can be mentally multiplied to indicate about the result that ought to be obtained, the process in the present instance being as follows:

In the numerator we have 25 and 4; then substitute 25 for 24, and 20 for the second 24, 3 for 3.1416 and 70 for 75.

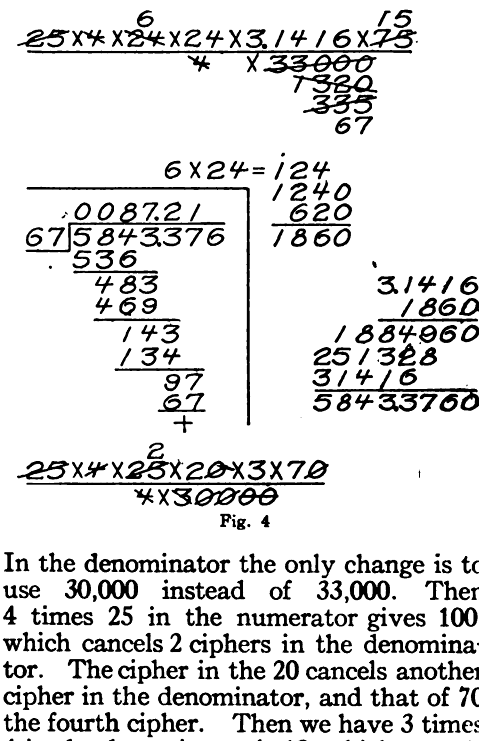


Fig. 4

In the denominator the only change is to use 30,000 instead of 33,000. Then 4 times 25 in the numerator gives 100, which cancels 2 ciphers in the denominator. The cipher in the 20 cancels another cipher in the denominator, and that of 70 the fourth cipher. Then we have 3 times 4 in the denominator is 12, which cancels approximately twice into 25, leaving us 4 simple factors, and we have 2 x 2 x 3 x 7, gives 84, showing that our result, 87.4, is correctly pointed off.

### FOR THE SLIDE RULE

Coming now to the case of the slide rule, we must remember that the slide rule knows no decimal point, that is, in making slide rule computations, 125, 1,250, or 12,500, or 1.25 are all the same, so far as the slide rule manipulations and readings are concerned. It is necessary, therefore, to have some rule for locating the decimal point, and we may do this by the regular method for arithmetical multiplication or division, or by a special method which applies only to the rule.

Take the case of Fig. 1. It is necessary to remember that the slide rule does not read to more than 4 significant figures, and that it is not important that it should do so, for in practically all engineering computations we are working with values which depend on test observation, and these observations are not accurate to more than one-half of 1 percent. It follows, therefore, that the slide rule is not a good instrument on which to figure the interest on a million dollars; but we are assuming that the interest on a million dollars is of only academic interest to our readers.

Put 1 on the *C* scale at 2,641 on the *D* scale; remember that each division between the marks of the 2 to 4 section of the rule represents 2 points, and the last figure 1 means that the 1 on the C scale is just a hair to the right of the 264 division of the *D* scale. We then carry the runner to 131 on the *C* scale and note that the remaining figures, 48, is practically the same as 50, so that the runner will stand half way between 131 and 132. Under the runner on scale *D* we shall then find 347 and a small fraction which we would estimate at 3.

From Fig. 1 we find that the absolutely accurate answer is 34,723, but 3,473 is as close as we can expect to come to it with a slide rule reading. It is evident that with only these 4 figures known, finding the decimal point by the rule for arithmetical multiplication is out of the question.

Many rules have been devised for finding the decimal point in slide-rule computations, but perhaps the simplest is that given by Wm. Cox. The index of any number is the number of figures in the integral part of the number; that is, the part to the left of the decimal point. The index of 125 would, therefore, be 3, of 1,250, 4, of 12.5, 2, of 1.25, 1, of 0.125, 0. If we go still further we have to resort to the negative index; that is, 0.0125 has 1 place less than nothing to the left of the decimal point and the index is, therefore —1. 0.00125 would have the index —2, and so on.

The rule given by Cox is that for multiplication; if the final product is read with the slide projecting to the left, the index of the product is the sum of the indexes of the factors, but if the slide is projecting to the right, the index of the product is the sum of the indexes of the 2 factors, less 1. In the example which we have just worked, Fig. 1, the index of 0.02641 is minus 1, and the index of 1.3148 is 1. The product is read with the slide projecting to the right, therefore the index for the product is minus 1 plus 1, which gives 0, less 1 equals —1, which indicates that there is one cipher to the right of the decimal point, giving 0.03473 as the product.

In case we want to know the foot pounds developed in a minute by an engine giving 8.7 h.p., we would multiply 87 by 33,000, which for the slide rule is 33. Setting 1 on the *C* scale to 87 on the *D* scale, we set the runner at 33 on the *C* scale and below it on the *D* scale we read 2,873, and the question arises, where is the decimal point. The index of 33,000 is 5; the index of 8.7 is 1; the answer is read with the slide projecting to the left, hence the index of the product will be the sum of the indexes of the factors, or 5 plus 1 equals 6, and there will be 6 places to the left of the decimal point, or the number will be 287,300.

For division, Cox gives the rule, if the quotient is read with the slide projecting to the left, the index will be the index of the dividend minus that of the divisor. If the slide projects to the right when reading the quotient, the index of the quotient is the index of the dividend plus 1, less the index of the divisor.

Take as an example, Fig. 2, to divide 2 by 785. We bring the runner to 2 on the *D* scale, now set 785 on the *C* scale to the mark on the runner. Under 1 on the *C* scale we then find on the *D* scale the reading 2,548, the slide projecting to the left. We then have the index of 2 is 1, and the index of 785 is 3; subtracting 3 from 1 gives us —2. The index —2 means that there are 2 ciphers to the right of the decimal point, and the quotient becomes then 0.002548, as shown in Fig. 2.

Again, suppose that we wish to divide 62.42 by 1,728. We set the runner to 6,242 on the *D* scale, and bring 1,728 on the *C* scale to the runner. Under 1 on the *C* scale, we find on the *D* scale the reading 361. The characteristic of

62.42 is 2, that of 1,728, 4, and the quotient is read with the slide projecting to the right. We have, therefore, that 2 the index of the dividend plus 1 equals 3, and less 4 the index of the divisor, gives —1, which is the index of the quotient. This means that there is one cipher to the right of the decimal giving 0.0361 as the quotient.

### COMBINED SLIDE RULE OPERATIONS

These rules work well enough in the case of a simple multiplication or division, but where there is a series of operations, particularly where multiplication and division are combined, as is frequently the case in the slide rule computation, the carrying out of the rule becomes so involved that a determination of the decimal point position by inspection is quicker and more accurate. For the case of Fig. 1, it is evident that 1.3 times 0.02 would be still somewhere near 0.02, so that the product would evidently be 0.03473. In the case of multiplying 33,000 by 8.7, it is easy to see that 8 times 30,000 would be 240,000, which shows that the product must be 287,300. In the example of Fig. 2 it is easy enough to jot down the 2 and the 785, as if the division were to be performed by arithmetic, and the position of the decimal point can in this way be quickly located by inspection.

In the case of a computation by means of slide rule of the example shown in Fig. 4, it is evident that after performing the operations on the slide rule instead of by cancellation, the location of the decimal point could be quickly checked out by the method shown at the bottom of Fig. 4, for testing the accuracy of its location when doing the problem by arithmetic.

To take the case of another example on the horse-power formula, if we have a double-acting engine with mean effective pressure of 23 lbs., stroke of 3 ft., piston 18 in. in diameter, running at 80 revolutions per minute, the expression for horse-power will be as shown in Fig. 5, the number of working strokes being twice the revolutions per minute, as the engine is double-acting.

To perform the operations indicated, perform first a division and then a multiplication, then a division and then a multiplication, and then continue the multiplications until all factors have been used. The first division is 23 divided by 4. We set the runner to 23 on scale $D$, and bring 4 on scale $C$ to the runner; then carry the runner to 3 on scale $C$, and bring 33 on scale $C$ to the runner; then carry the runner to 3.1416 on $C$, which will be a trifle to the right of the 314 reading. All the divisions have now been accomplished, the remainder of the work is multiplication, and we bring 1 on $C$ to the runner, then carry the runner to 18, bring 1 to the runner, carry the runner to 18, bring 1 at the right-hand end of the slide to the runner and carry the runner to 8, then bring 1 to the runner and carry the runner to 2. Then at the runner mark read on scale $D$ the answer, which is 852.

It remains to determine the decimal point, and this is most easily done by the same process of approximate cancellation as was used in the arithmetical

$$\frac{23\times3\times3.1416\times18\times18\times80\times2}{4\times33000}=85.2$$

$$\frac{\cancel{2}\cancel{0}\times\cancel{3}\times3\times\cancel{2}\cancel{0}\times2\cancel{0}\times8\cancel{0}\times2}{\cancel{4}\times\cancel{3}\cancel{0}\cancel{0}\cancel{0}\cancel{0}}=96$$

Fig. 5

computation of Fig. 4. This is indicated in the lower part of Fig. 5. We first cancel the 4 ciphers in the numerator against the 4 ciphers of the 30,000 in the denominator. One of the 3's in the numerator cancels with the 3 in the denominator, and the 4 in the denominator cancels 2 of the 2's in the numerator, leaving as factors 3 x 2 x 8 x 2, which is easily figured mentally to equal 96, so that it is evident that the correct result is 85.2.

As a result of years of experience using the slide rule, the writer has adopted the method of inspection and approximate cancellation as the quickest and most accurate method of determining the position of the decimal point. While the method of index is easy in a single computation, it involves keeping track of the projections of slide to right and left as the work progresses, and this takes the mind from the settings so that it is likely to cause errors in readings. Even if correctly done, it will take more time to keep track to work out the index than to perform the approximate cancellation, and that cancellation gives an approximate check on the correctness of the slide rule manipulation as well as the position of the decimal point.

## FITTING HINGES

W. J. HORNER

The three types of hinges shown in Fig. 1 are those in common use. They vary in size and details, but not very much in their proportions. The shape of the butt-hinge adapts it for attachment to narrow edges of wood, as those of doors and box-covers. The length

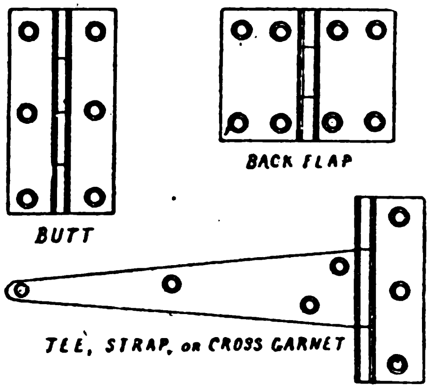


FIG. 1.

of its pivot or knuckle is greater than the extension of its flaps. In the back-flap hinge these proportions are reversed, the length of the knuckle being less than the measurement across the flaps. This type of hinge is used on broad surfaces, and chiefly for a rougher class of work than butts. The tee-hinge is used similarly, its extremely long extension serving as a brace and stiffener to a broad surface of comparatively thin wood.

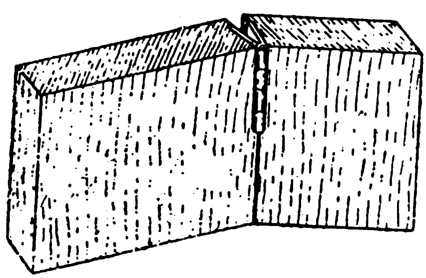

FIG. 2.

The butt-hinge is fitted as in Fig. 2, generally sunk into the wood, but not necessarily so. As far as the hinging of the parts is concerned, the effect is the same if it is screwed on the outer surface, as in Fig. 3, instead of in the joint, as in Fig. 2; but a back-flap hinge is more

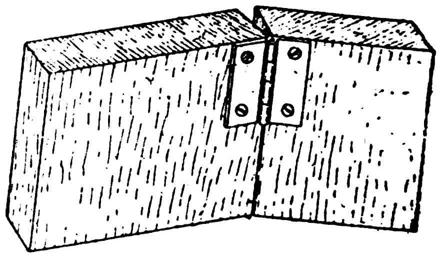

FIG. 3.

suitably proportional for such a position. When a butt-hinge is used, as in Fig. 2, long screws can be inserted, and there is no risk of their tearing out or of the wood breaking away. If it is attached as in Fig. 3, the screws are rather close to the edge and strain on the hinge tends to split the wood away. For this reason a back-flap, or a tee-hinge, as in Fig. 4, is preferred for attachment to the outer surface. The former is occasionally

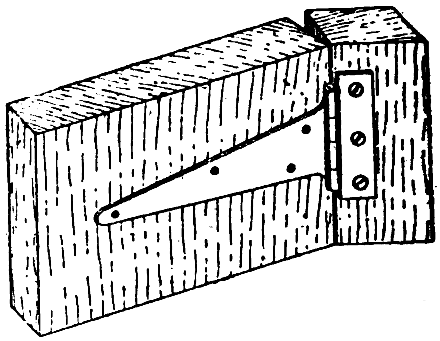

FIG. 4.

sunk flush with the surface, but the latter never is, being simply adjusted in the required position and screwed on. The butt-hinge, used as in Fig. 2, must be sunk in order to make a close joint between the hinged parts; but when the hinge is placed as in Figs. 3 and 4, its thickness does not interfere with the closeness of the edge joint, but only with

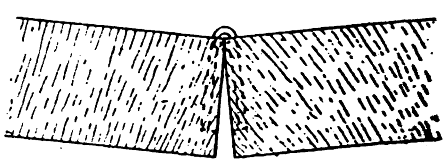

FIG. 5.

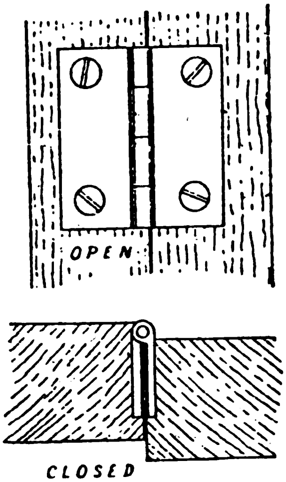


FIG. 6.

the closeness of the broad surfaces, if they are folded back against each other.

Generally it is easier and quicker to attach a hinge as in Fig. 3 than as in Fig. 2. The parts to be hinged simply have to be placed in position, with their edges in contact, and the hinges screwed on, care being taken to set their knuckles central over the joints. In many cases the parts can be laid flat on a bench while this is being done. If the hinges are to be sunk flush with the surface they are laid in position, lines marked round them, and the recesses chiseled out to correspond with the thickness of the flaps. Then the hinges are inserted and screwed.

In attaching butt-hinges, as in Fig. 2, the procedure is not quite so simple, for the parts can seldom be placed as conveniently. The hinges must be fitted to one of the parts first, and this held in position for attachment to the other. They must be sunk to exactly the right depth or the joint will either be open or will bind and not close properly. The latter defect is shown in Fig. 5. The hinge there is sunk too deeply, and the edges of the wood at the knuckle bind and prevent the farther edges from coming into contact at all. The joint might be closed completely by the use of force, but it would spring open again as soon as released. The remedy is to take the hinge off and replace it with cardboard packing beneath, or plane the wood down to reduce the depth of the hinge recesses.

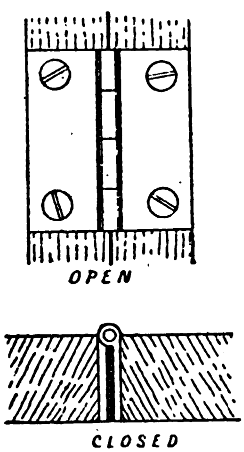


FIG. 7.

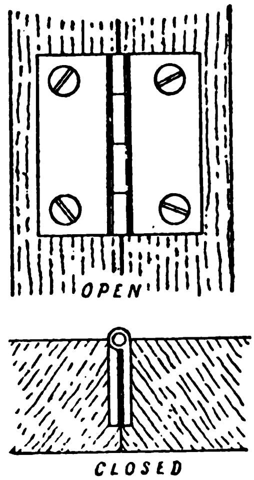


FIG. 8.

Another defect is shown in Fig. 6. The hinge there is sunk correctly, but is out of center. In the view showing the hinge open the center line of the knuckle is to one side of the joint. The consequence is that the surfaces of the parts are not flush with each other when the hinge is closed.

Figs. 7 and 8 show butt-hinges attached correctly. In Fig. 7 the hinge is the full width of the wood; in Fig. 8, it is less, and the recesses are, consequently, not cut right across. Fig. 8 is the neatest and most frequent method; but when the wood is thin the hinges sometimes have to correspond with it, as in Fig. 7. In other cases, where thin wood is hinged to a thicker piece, a combination of the methods is followed, one flap of the hinge extending the full thickness of the wood, and the other having wood extending beyond it.

The flaps of a hinge have to be sunk slightly more than their thickness, for the wood to make a close joint when closed. This is because the flaps are always made thinner than half the diameter of the knuckle. When a hinge is closed, with its flaps parallel, there is a space between them about equal to the thickness of another flap. This space must

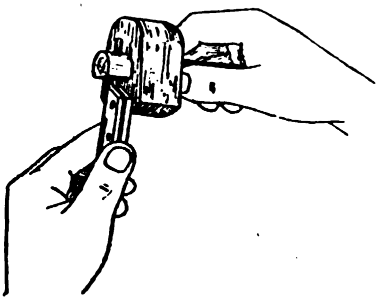

FIG. 9.

exist when the hinge is fitted; but the wood should form a close joint, as shown in Figs. 7 and 8. The correct depth for the recesses is marked on the wood with a gauge, which is set, as in Fig. 9, to the center of the knuckle. When this has been gauged on the wood the measurement in the other direction is taken, as in Fig. 10, from the outer edges of the flaps to the center of the knuckle. The length of the hinge is marked, as in Fig. 11, by laying it in position on the wood.

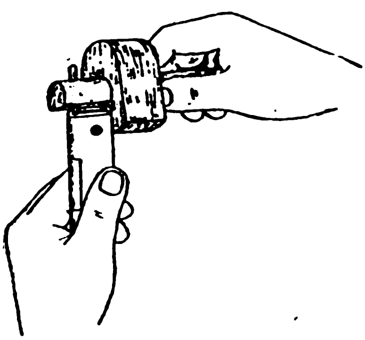

FIG. 10.

When hinges are simply screwed on the surface, without being let in, no gauging or marking is necessary, unless, perhaps, measurement with a rule, to get them at uniform distances. They are placed in position, screw-holes bored with a brad-awl, and the screws inserted.

Box covers are hinged, as in Fig. 12,

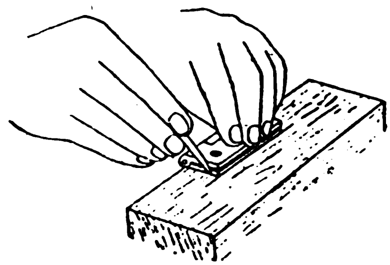

FIG. 11.

one flap of the hinge being on a narrow edge and the other on a broad surface. In this case also there is the alternative of putting the hinges on the outside, instead of in the joint; but the latter is the neatest and the usual way. The hinges are put on the lid first, as in Fig. 13, and this is held in position, first for

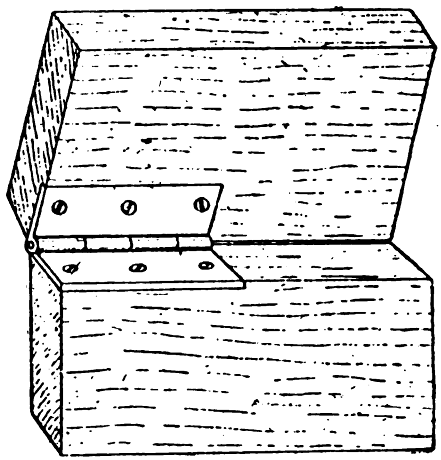

FIG. 12.

marking the lengths of the recesses on the box, and, finally, for screwing the hinges. It is better to complete the fitting of the hinges to the cover before marking their position on the body of the box, though the lines of thickness and width may be gauged on both simultaneously.

(*Continued on page* 196)

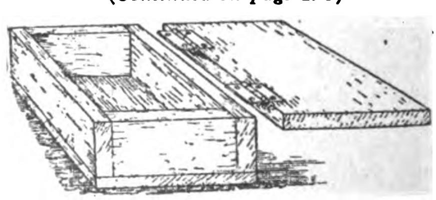

FIG. 13

# *RECENT DEVELOPMENTS IN THE MANUFACTURE OF INCANDESCENT ELECTRIC LAMPS

## Carbon Filament Lamps—Metal Filament Lamps—Osmium, Tantalum and Tungsten Types—Experiments with Tungsten Pastes—Ductility as a Factor

J. E. RANDALL

By common usage, the name, incandescent electric lamp, has been limited to a lamp whose light source is the glow of a wire heated in vacuo by electric current. This article will not use the name in any broader sense.

Incandescent electric lamps may be divided into two classes, depending upon whether their light-giving elements, that is, their filaments, are made of carbon or of metal. At present the best examples of each class stand rather far apart, both in appearance and in other features, although both are designed for the same service. One may be replaced by the other for nearly every use.

Lamps with carbon filaments have been supplied without any change in appearance for over eleven years. Within that period one notable improvement was introduced, namely, the metallized filament. Among the lamps with metal filaments, there has been, within the last five years, a procession of developments beginning with the osmium filament, the tantalum wire filament, the pressed tungsten filament, and ending with the drawn-wire tungsten filament. The author shall attempt to briefly review the advances that have been made in the quality of the most prominent members of the two classes.

### CARBON FILAMENT LAMPS

The changes in quality of the regular carbon filament lamps of all standard wattages are shown in the subjoined table. Each year's quality is shown in comparison with the average of 1902.

| Year ....... | 1902 | 1904 | 1906 | 1907 | 1908 | 1909 | 1910 |
|---|---|---|---|---|---|---|---|
| Pct. of 1902 | 100 | 98.4 | 96.9 | 96.9 | 100 | 103.1 | 107.8 |

A sag in quality is indicated from 1904 to 1907. This is accounted for by the larger proportion of wattages below 50 and above 100, that were produced during those years. The large and small wattage lamps are known to be inferior to those between 50 and 100 watts. Within recent years the production of high wattage lamps has diminished, and doubtless will decrease still further. The proportion of low wattage lamps has been maintained and has held back the progress of average quality during the last three years. As a matter of fact, nearly every wattage shows a substantial improvement within the eight-year period.

No changes have been made in the processes of manufacture. The record exhibits the results of systematically following each detail, of rigid inspection, of thorough, exact and extensive tests, of the immediate use of the latest developments in equipment and the unhesitating discard of unsuitable equipment, of the services of trained operatives. The best lamps of ten years ago were as good as the best of the present year. The average has arisen due to the elimination of defectives.

The metallized carbon filament lamps, which are known as Gems, have made the advances shown by the following record: Calling the product of 1907 equal to 100; that of 1908 is 121; that of 1909 is 130; that of the year 1910 is 133.

All conditions favorable to advancement of the regular carbon filament lamps were of similar assistance to the Gems. A discovery in connection with the preparation of the carbons for these lamps resulted in a decided improvement in 1909. Heretofore, wattages lower than 50 have not been made successfully. Recent experiments show that wattages as low as 30 can be made.

The Gem lamp shows a sufficient superiority in quality over the regular carbon filament lamp to justify its more extensive use.

### METAL FILAMENT LAMPS

As the developments in three metal filament lamps have been rapid, recent, and thoroughly published, no extended description will be given in this article.

The osmium lamp marks the beginning of development of metal filament lamps.

* Paper read at the fifth annual convention of the Illuminating Engineering Society, Chicago, September 25–28, 1911.

It reached a successful commercial stage in Europe. Its great fragility and the difficulties met in fashioning the filament would, no doubt, have been eliminated had its development not been arrested by the limited supply of osmium and by the advent of the tungsten filament.

The tantalum, nearly coeval with the osmium, was handicapped neither by fragility nor meager supply of metal. It is worthy of mention as an example of an article upon whose production years of research had been spent, upon whose design lavish experiments had been made. When first offered to the public, its design was finished and its qualities were thoroughly known. The inferior performance, due to offsetting, on alternating current was announced at the time the lamp was announced. The mechanical weakening of the tantalum wire, due to offsetting when kept on alternating current, has prevented the general introduction of the tantalum lamp in this country.

This lamp, however, was the first production of a real drawn wire lamp, and its development required a construction of the filament-supporting element different from any that had been used before. The design of support employed in the tantalum lamp has been followed, with slight modifications, in the drawn wire tungsten filament. The tantalum lamp cannot continue to compete with the drawn wire tungsten filament lamp in its present form.

The tungsten filament lamp was the immediate successor of the osmium lamp, and one of the most successful methods of producing the tungsten filament is based upon the process used in making the osmium filament. The completely developed process, however, has departed considerably from the method originally used, and it is doubtful whether the osmium filament could be produced by the methods now employed in the manufacture of the pressed tungsten filament. Various experimenters quickly discovered other methods of producing pastes from which tungsten filaments could be pressed. The most successful commercial methods are, however, really variations of the original Auer process.

The superiority of the metal tungsten for a lamp filament was immediately recognized, because of its extremely high melting point and because its boiling point is not greatly below its melting point. The brittleness of the pressed filament, especially when it is cool, has been a serious drawback to the general use of the lamp. The attachment of the filament rigidly to the circuit connections and to the intermediate connections between the filaments has probably been the chief cause for filament breakage in these lamps. The arced joint, while it was perfect electrically and mechanically, held the filament ends rigidly. Any jar to the lamp tended to make the filament vibrate and usually to break close to the joint. The schemes that were devised for avoiding this filament breakage were legion, but the author believes he is safe in saying that the loose contact at the bend of the filament with a support that was rigid made the hardiest lamp of the pressed filament type.

One of the most successful devices for preventing the breakage of filaments was that of introducing a short piece of piano wire between the center rod and the stem seal. This supported the filament structure with remarkable flexibility and prevented a breakage from blows on the lamp in almost any direction. A slight blow upon the base of the lamp was invariably fatal and this one weak feature served to prevent the general introduction of this method of support.

The pressed tungsten filament is not ductile when cold, no matter by what process it may have been produced. Although pressed filaments have been made that could be bent and that would take a permanent set if bent, these filaments were not truly ductile. It was natural, therefore, that immediate effort should be made to develop a quality of tungsten sufficiently ductile to be wrought into the form of wire. There was nothing to prevent success in this endeavor except lack of knowledge. It had been demonstrated that tantalum, which had been known as an extremely brittle metal, could be so improved in purity that it would be ductile. This knowledge would naturally lead to the belief that many of the metals which had been considered as non-ductile could, if properly prepared, be made into ductile form. An epitome of the progress in developing ductile tungsten will read something like this:

In 1907 it was hoped that it would be

possible to produce ductile tungsten; in 1908 it was believed that it would be possible to produce ductile tungsten; in 1909 experimenters were sure that ductile tungsten could be produced; in 1910 it had been proven beyond doubt that ductile tungsten could be produced; in 1911 ductile tungsten was produced on an extensive commercial scale.

It is generally believed that the presence of carbon in tungsten is the cause of its brittleness. One well-known process for making pressed tungsten filaments does not involve the use of carbon, yet filaments produced by this process are as brittle as are filaments made by the use of carbon. As a matter of fact, the best pressed tungsten filaments have been those made by processes involving the use of carbon, yet they contain an amount of carbon so small that it can only be detected by the most delicate tests. For instance, filaments which are known to contain less than 0.005 percent carbon are no more ductile than those which are found to contain 0.1 percent. The elimination of carbon tended to reduce the length shrinkage of filaments when lamps were burned. You will doubtless recall that filaments produced in 1908 and 1909 sagged excessively and that the filaments often short-circuited due to the sag. The slack producing this sag was necessary because of the filament shrinkage. During the year 1909 decided improvements were made in this respect, and the basis of these improvements was the more complete elimination of carbon from the tungsten filament.

The progress during 1909 and 1910 did not indicate a material decrease in the fragility of the pressed filament.

It was evident, therefore, that to make the tungsten filament lamp a universal lamp, it would be necessary to have the filament in the form of wire which was sufficiently ductile to be wound, when cold, upon a spider structure. The drawn tungsten wire has met this need. While the wire before being placed in the lamp is amply ductile for the purpose of winding upon the spider and for all other manipulations needed in making the lamp, it loses much of this ductility when current is passed through it in a vacuum. The method of supporting the wire on the spider and of attaching it to the circuit terminals are, therefore, important factors in the hardiness of the lamp.

The wire may be considered to consist of pure tungsten. Chemical analysis does not find other elements. The ratio of resistance hot to resistance cold is as high as can be found in any form of the metal. The specific gravity is higher than that found for the pressed filament. The current and the candle-power peaks are low.

The structure of the metal appears to be fibrous. It changes to the crystalline form during the burning life of the lamp. This change may occur in some portions of a filament and not in others. Frequently, after the full burning life, small sections of filaments will be found that show ductility.

Tests indicate that the wire is less brittle at every stage in the life of a lamp than are pressed filaments. There is no offsetting, either on direct or alternating current. The surface is the same in appearance, after the lamp has been burned, as that of a pressed filament. It looks as if the wire had been cracked into irregular pieces, and as if a cement of the same material had filled up the cracks. No fissures at the surface and no cavities in the body have been found.

While the wire, before being placed into the lamp, may be ranked with the toughest steel in tensile strength, ductility and elasticity, the decay of these properties after it is in the lamp makes it necessary to handle these lamps with reasonable care in order to prevent breakage. Breakage in transportation and handling compares with that for carbon filament lamps. Operatives in the lamp factories transfer lamps having wire filaments from operation to operation the same as if they had carbon filaments.

Another feature in which the drawn wire is superior is the wide range of sizes suitable for use. A piece of wire may be drawn to a size suitable for a 6.6 amperes series burning lamp or it may be drawn to a size suitable for a 20-watt, 110-volt multiple lamp. It will, when drawn to the proper diameter, be equally satisfactory for the largest or the smallest lamp. In addition, the wire may be shaped into helices, spirals or zigzags; thereby concentrating the light-giving element into a small volume. The latest automobile lamp is an example.

The number of contacts between the filament and supports, including terminals, as well as the size and material of these supports, will affect the performance and physical hardiness of a lamp.

The following results were secured from three series of tests in each of which more than 300 drawn wire tungsten filament lamps were used:

| | | | |
|---|---|---|---|
| Number of contacts | 11 | 13 | 15 |
| Comparative strength, by pendulum test: | | | |
| Copper | 91.5 | 100 | 96.5 |
| Molybdenum | —— | — | 93.0 |
| Comparative performance at normal efficiency: | | | |
| Copper | 99.4 | 100 | 96.1 |
| Comparative life at extreme temperature: | | | |
| Copper | 107.0 | 100 | 87 |
| Molybdenum | —— | — | 103 |

The lamps were standard in voltage and all were 40 watts. They were identical, except in the number of filament contacts. The results of the first and second tests confirm one another in indicating that 13 contacts are most satisfactory.

While no record is shown for molybdenum support lamps at normal efficiency, such lamps were tested, but their performance was much more poor than the corresponding copper support lamps.

The comparative lives at extreme temperature show that 11 contacts are better than 13 and that 13 are better than 15. Also that 15 molybdenum contacts are better than 13 copper, but inferior to 11 copper. These results are not in consonance with the results at normal efficiency. It is reasonable to believe that tests at, or near, normal efficiency indicate more accurately the behavior of lamps in service than do those at high temperatures. It has been observed that the wire in lamps burned out when at high temperature remains more ductile than the wire in lamps burned out at normal temperatures. The early failure of 15 contact lamps would not be explained by mechanical weakness. The wires usually "burned out," or melted, between the supports. The melting of the wire at the point of highest temperature has really controlled the life record of this test. The diameter of all copper supports was the same. The diameter of the molybdenum was 40 percent of that of the copper. Supports of copper having diameters 30 percent smaller and 30 percent larger than the size used in the above tests, both showed a lower strength by pendulum test. The author cannot explain why this should be so, but the tests were convincing.

Having traced recent developments up to the latest, it may not be amiss to consider the future. If the progress in lamp development may be gauged by the highest filament temperature at which each new lamp will show a given performance, one has a rational measure. For example, if 90 percent of the theoretical candle-power hours are developed in 1,000 hours burning, candle maintenance and mortality both considered, the advance from the raw carbon filament lamp to the tungsten lamp will show something as follows:

| | |
|---|---|
| Raw carbon filament lamp (cellulose carbon) | 100 |
| Treated carbon filament lamp | 119 |
| Metallized carbon filament lamp | 149 |
| Tantalum filament lamp | 206 |
| Osmium filament lamp | 270 |
| Tungsten filament lamp | 359 |

This comparison excludes many items, such as process difficulties, lack of wattage range, lack of voltage range, lack of suitability for both alternating and direct current, cost, etc., which affect commercial values. It is not a comparison of commercial values, although it is a comparison of the most important element in commercial values, namely, the energy wasted in doing equal work.

The change introduced by the metal filament lamp is noteworthy. Can carbon, with its many good qualities, reach or pass the record set by metals? The carbon deposited upon the treated carbon filament, when metallized, is dense, somewhat flexible, has a low vapor tension, has a fine quality of surface and has a cold specific resistance that is about 4 percent of carbon made from cellulose. All these qualities are favorable. Their further development may again place carbon in the race.—*The National Engineer.*

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The total consumption of coffee in the United States in 1910 was 860,414,000 lbs. or an average of 9.33 lbs. per individual. There is only one other nation that consumes more coffee per capita than the United States and that is the Netherlands, where the consumption amounts to 15.12 lbs.

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A man should never be ashamed to own he has been in the wrong.—Pope.

# ELECTRO-CHEMISTRY

ERNEST C. CROCKER

Electro-chemistry is the branch of chemistry which concerns itself with the applications of electricity to chemical problems, and chemistry to electrical problems. In order to understand the inter-relations of chemistry and electricity, it is first of all necessary to have clear ideas concerning both, and these clear ideas are best formed when we attack the very heart of the problem, the ultimate nature of matter itself and of electricity.

To most people it must seem to be the height of presumption to speak of molecules, atoms and electrons as though we had seen them and knew they really existed. It is true that there is still much speculation concerning these; but a speculation that is founded upon experimental results and which always returns to experiment in case of doubt cannot be misleading. Although, in this department the different chemical and electrical concepts will be spoken about as though their existence and behavior were well known, this attitude is taken only for the sake of clearness, and, furthermore, it will be an overwhelming discovery which will overturn the system upon which these assumptions are based.

We are in possession of many excellent and plausible theories, some the products of the world's greatest minds, which seek to explain the nature and origin of matter and electricity; but, for obvious reasons, we must turn them aside, unless they should be the expression of the results of the experimental scientist. If we hear the words of the experimenter, and doubt their truth, the only thing left to us is to experiment for ourselves and either disprove or verify his statements.

It is our aim in this article to set forth correct ideas concerning electricity and chemistry, which will stimulate the readers to attack investigations, and to attempt to satisfy that yearning to know the "why" of the problem which is so strong, particularly in the younger readers.

All pertinent questions will be cheerfully answered.

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## THE ULTIMATE NATURE OF MATTER

Experiment shows us that it is possible to cause two substances to combine and form a third substance which has few properties in common with the original substances. It furthermore shows that substances combine in a definite proportion, and that if we have an excess of either original substance it remains uncombined. In some cases two substances can combine under different conditions, in two or more proportions, but these are always in simple relation to each other as 2 to 1, 3 to 2, etc. After observing hundreds of cases of definite combination, by weight, it occurred to chemists that when two substances united, they formed a definite "compound," rather than a simple mixture.

To illustrate: Let us add 56 parts by weight of iron filings to 32 parts by weight of sulphur and mix them well. If, after mixing, we hold a magnet near the mixture, we can separate all the iron from the sulphur. Let us mix the substances together again, and put the mixture in a glass tube and heat the tube over a gas flame; all at once a glow begins in one spot and quickly spreads throughout the entire mass. When the glow is over and we cool and examine the substance, we find that a magnet can no longer pick out the iron, nor can we find any evidence of the sulphur. A chemical change has taken place and we have a definite compound, iron mono-sulphide, which is expressed in chemical shorthand by the symbol $FeS$. This substance can be used in place of the very similar compounds Chalcopyrite and Bornite, in wireless telegraphy, in a "Perikon" detector. In nature there occurs a mineral "iron pyrites," which analysis shows to be a compound of iron and sulphur, but here the amount of sulphur which combines with 56 parts of iron is 64 and not 32 parts, and we have iron di-sulphide $FeS_2$. This is the mineral "Pyron" or "Ferron" used in wireless telegraphy. Iron mono-sulphide can be formed artificially by heating iron and sulphur together, but iron di-sulphide is found in nature, in rocks, as a deposit from certain mineral waters.

Water, a compound of hydrogen and oxygen, two gases, has the formula $H_2O$. If we add a drop of acid, or a little salt, to a glass of water (to make the water an electrical conductor) and pass an electric current through the water, using two platinum wires as leads, we shall find that gases are evolved at each wire. If we collect the gases evolved, in the manner shown in the illustration, it will be found that there is evolved just twice as much hydrogen gas at the negative terminal as there is oxygen gas at the positive terminal. On testing tubes full of each gas with a lighted match, it will be noticed that one gas, the hydrogen, burns, while the other, the oxygen, makes the match burn more vigorously. This is an application of electricity to chemistry, as a method of analysis; but at the same time can be used as a chemical method of finding the direction of an electric current, for if ever two terminals of an electric circuit are plunged into water, the most gas is always given off at the negative terminal.

The fact that compounds contain definite proportions of different "elements" or simple substances, led to the belief that all elements are composed of definite small particles, "atoms," which unite in twos, threes, etc., to form the compounds. This belief has been so completely justified that, although nobody has seen the atoms, it is no longer reasonable to doubt their existence. The little groups of two or more atoms of which substances are composed are called "molecules," or little masses.

By careful observation of the combining weights of the different elements, it has been possible to obtain the relative weights of the atoms of the elements, and a table of such values is here given. Originally, hydrogen was taken as unity, but it was later found more convenient to take oxygen as exactly 16, which makes hydrogen 1.008. By carefully looking over the table it will be seen that, with the single unaccountable exception of iodine (126.97) and tellurium (127.6), there is a gradual increase of values from 1.008 for hydrogen to 238.5 for uranium. The "valence," an electro-chemical property of the atom which we shall consider later, determines the vertical column (group), and the atomic weight determines the series, in which an element is placed.

This remarkable table of progressive weights suggests that perhaps all atoms of "elements" are made of an original mother-substance, the atomic weights indicating the relative amounts of this substance present. Some of the recent work with the heavier elements, uranium, thorium and, most particularly, with radium, has shown that the atoms of these elements (?) are slowly disintegrating into lighter atoms, of which helium is one. Although radium is the most prominent example of a disintegrating atom, this disintegration is found in the case of a number of other atoms, including even the light-weight element potassium, and there is reason to believe that disintegration is a common property of all elements.

There have been many elaborate theories advanced as to what the original mother-substance may be, some having it "ether," some "electrons," some a single simple substance, and some a combination of two or more elementary substances. All we can say about this, just at present, is that we must wait for a few years until there is advanced some generally acceptable theory which agrees with the facts. All that we know is that what we call atoms are really not elementary particles, but are complicated structures.

Many attempts have been made to disintegrate atoms, but up to the present time, nothing but failure has resulted—we only know of disintegration where it occurs spontaneously, and even there we cannot yet hasten or retard it. It is difficult to say what may be done by, for instance, a more intense heat than any which we can now produce, or by some peculiar application of electricity.

Although we cannot clearly understand all about the atom, it possesses some peculiar properties which are of interest both to the chemist and to the electrician. All atoms do not combine with each other in equal numbers, although always in a simple ratio, nor do they have equal tendencies to combine—in fact, there are elements which will combine with no other elements, or their valence is zero (group 0 in the table).

## TABLE OF SYMBOLS AND ATOMIC WEIGHTS

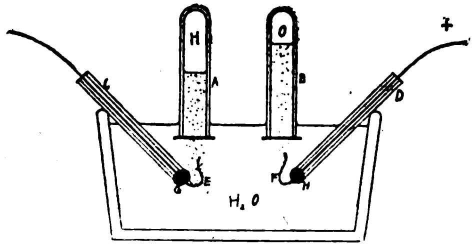
NOTE: The names in parentheses are the Latin names of the elements

| Group | 0 | I | II | III | IV | V | VI | VII | VIII |
|---|---|---|---|---|---|---|---|---|---|
| Valence | 0 | 1 | 2 | 3 | 4 | 3 or 5 | 2 or 6 | 1 or 7 | 2 or 8 |
| SERIES 1 | | Hydrogen H 1.008 | | | | | | | |
| 2 | Helium He 4 | Lithium Li 7.03 | Beryllium Be 9.1 | Boron B 11 | Carbon C 12.00 | Nitrogen N 14.04 | Oxygen O 16.000 | Fluorine F 19 | |
| 3 | Neon Ne 20 | Sodium (*Natrium*) Na 23.05 | Magnesium Mg 24.36 | Aluminium Al 27.1 | Silicon Si 28.4 | Phosphorus P 31.0 | Sulphur S 32.06 | Chlorine Cl 35.45 | Iron (*Ferrum*) Fe 55.9 |
| 4 | Argon Ar 39.9 | Potassium (*Kalium*) K 39.15 | Calcium Ca 40.1 | Scandium Sc 44.1 | Titanium Ti 48.1 | Vanadium V 51.2 | Chromium Cr 52.1 | Manganese Mn 55 | Nickel Ni 58.7; Cobalt Co 59 |
| 5 | | Copper (*Cuprum*) Cu 63.6 | Zinc Zn 65.4 | Gallium Ga 70 | Germanium Ge 72.5 | Arsenic As 75 | Selenium Se 79.2 | Bromine Br 79.96 | Ruthenium Ru 101.7 |
| 6 | Krypton Kr 81.8 | Rubidium Rb 85.5 | Strontium Sr 87.6 | Yttrium Yt 89.0 | Zirconium Zr 90.6 | Columbium Cb 94 | Molybdenum Mo 96 | —— | Rhodium Rh 103.0; Palladium Pd 106.5 |
| 7 | | Silver (*Argentum*) Ag 107.93 | Cadmium Cd 112.4 | Indium In 115 | Tin (*Stannum*) Sn 119.0 | Antimony (*Stibium*) Sb 120.2 | Tellurium Te 127.6 | Iodine I 126.97 | Europium Eu 151.79 |
| 8 | Xenon Xe 128 | Caesium Cs 132.9 | Barium Ba 137.4 | Lanthanum La 138.7 | Cerium Ce 140.25 | Didymium Di 140.5 | Neodymium Nd 143.6 | Samarium Sm 150.3 | ——; —— |
| 9 | | Gadolinium Gd 156 | Terbium Tb 160 | Erbium Er 166 | —— | —— | —— | Thulium Tm 171 | Osmium Os 191 |
| 10 | —— | —— | —— | Ytterbium Yb 173.0 | —— | Tantalum Ta 183 | Tungsten (*Wolfram*) W 184 | —— | Iridium Ir 193 |
| 11 | | Gold (*Aurum*) Au 197.2 | Mercury (*Hydrargyrum*) Hg 200.0 | Thallium Tl 204.1 | Lead (*Plumbum*) Pb 206.7 | Bismuth Bi 208.5 | —— | —— | Platinum Pt 194.8 |
| 12 | —— | —— | Radium Rd 226.5 | —— | Thorium Th 232.5 | —— | Uranium U 238.5 | —— | ——; ——; —— |
| Higher Oxides | None | $R_2O$ | RO | $R_2O_3$ | $RO_2$ | $R_2O_5$ | $RO_3$ | $R_2O_7$ | $RO_4$ |
| Hydrides | None | | | | $RH_4$ | $RH_3$ | $RH_2$ | RH | |

Save this table, as it will be referred to in succeeding articles.

Oxygen and fluorine are very active elements and not in this group, yet it has never been possible to make them unite, and even though both are of such activity that either unites with hydrogen with explosive violence.

The simplest explanation of the attraction (sometimes explained by simply calling it "chemical affinity") is that of electrical attraction between the atoms of the different elements. Some are negatively and some positively charged,—and the greater the available potential, the more active the element. Oxygen and fluorine are practically equally charged, but both negatively, hence their mutual repulsion. The electrical potential is supposed to be due to the presence of little particles of negative electricity, "electrons," which, while they belong to the atom, are free to move about within the atom, which itself bears the positive electricity. Evidently, if there are just enough electrons present to form an amount of negative electricity just equal to the positive electricity of the




atom, the atom as a whole will be neutral, while, if not enough are present it will be positive, or if too many are present, negative. Very few atoms are exactly neutral, there being usually an excess of one or other kind of electricity. Actual justification for this electrical explanation of chemical attraction will be found when we consider the inner workings of electric batteries.

"Valence" is easily explained, for it also appears to be electrical in its nature. Valence is the combining power of an element; for instance, an atom of valence 4 needs either four atoms of valence 1, two atoms of valence 2, or one atom of valence 4 to form a compound. Four atoms of valence 3 also unite with three atoms of valence 4. It seems that a valence 1 atom has one electron in excess or lacks one, an atom of valence 2, two electrons, etc.

Although chemistry and electricity are ordinarily separate studies, they may advantageously be combined to explain each other. We have considered the granular structure of matter and the existence of the electron, and from time to time we shall find things which demand a knowledge of the electron as well as the atom or molecule and shall find many places where, as in X-rays, electrolytic rectifiers and batteries, the electrical action can only be understood when we know the chemical action.

## BELL WORK IN NEW HOUSES

W. F. PERRY

Ordinarily an electrician who is wiring in a new frame house lets the bell-work remain until last, then this is pulled in with wonderful rapidity, simply because it does not have to be insulated. Owing to this fact, the wires are run over, around and through anything and everything, joints being made between walls and ceilings. In one year, or possibly less, the bell is out of order, the electrician sent for, the test made and a line found to be broken inside somewhere, so that another wire has to be run. Many times this line has to be run in plain sight, the owner knowing that pulling his house to pieces for so small a job is a needless and a foolish undertaking. In a few years' time, the closets, back-stairs, and cellar-way is a maze of dusty and dirty bell wire, some of which are useless and one or two of which perform the duty which each in its turn had done.

To overcome this difficulty, the writer installs all bell wire, no matter how long or how short, in a manner such that, if any trouble is found on a line, that one line may be pulled out without disturbing any other wire. The plan is to take each and every wire into the cellar in a perfectly straight line, there being no fastenings whatever for them.

A piece of ⅞ in. board should be fastened flush with the studding and a hole bored through it with a No. 11 bit. Holes should be bored right through to the basement, care being taken to get them somewhere near in line. A small piece of lath will suffice to hold the wire from falling back through the hole by twisting the wire around it. In the cellar, a nail may be driven in and the wire tied to it. The button wires at the door should be done as nearly as possible in the same manner. Of course they have to pass through one or more studs at right angles; but if care is taken in cutting the holes, the wires will be free to slide back and forth.

After the house is completed and the bells and buttons in place, the loose ends in the cellar should be connected. This requires a little work in the basement, but all the joints are in plain sight.

Now, if, after a year or so, trouble is found on any concealed wire, that wire is disconnected from its bell or button and from the nearest joint in the cellar, and a new piece of wire of the proper length tied on—by loosening the plaster away from it, where it passes through the wall, the old wire may be pulled out, and the new one pulled in behind it.

With this method, the closets and stairways are always free from loose wiring, and the electrician always knows it is but a simple matter to repair it.

## MOVING PICTURE MARVELS

Every day fifteen million people attend the moving picture shows throughout the country, but despite the evident popularity of the amusement, there are few who understand how the many mystifying effects are produced.

Men walk on ceilings like flies, or run up the sides of houses in apparently entire disregard of the law of gravity. Horses, dogs, cats and other animals walk backwards or sideways in a manner quite contrary to their usual nature; coffee pots proceed to pour themselves without any visible interference; automobiles dash through crowded streets in defiance of all speed laws; men and women fall down steep inclines and over the edges of precipices and get up again, apparently none the worse for their experience; real trains collide, and real ships are wrecked without regard to the expense involved—and all for the modest price of a nickel or a dime, says *Boston American*.

How is it done? The answer may be told in two words: It isn't. It's all make-believe. Real persons and animals pose for the pictures, and the scenery is sometimes genuine, but that is all. The rest, for the most part, is just make-believe, as a visit to the great studios where moving pictures are made would readily demonstrate.

Some of the most amazing effects are easily accomplished by a tactful manipulation of the film; others require more elaborate preparations. To make an animal walk backwards, a moving-picture is taken of it walking in the usual manner, and to produce the desired effect the film is simply reversed. In the same way the really astonishing pictures of brick apparently flying into a bricklayer's hod are obtained, the simple operation of a man dumping a hodload of bricks being sufficient to give the fantastic effect when the film is reversed.

Everyone who has visited a moving picture exhibition is familiar with the ease with which moving picture heroes and heroines run nimbly up the sides of houses when pursued, and, no doubt, everyone has wondered at one time or another how the feat is accomplished.

There are two ways of doing this: One is to have the person posing for the picture drawn up the side of a real house by means of a rope, moving his feet all the time, as though he were walking, the rope being afterwards painted out on the film; the other and more common way is to make the film in a specially prepared studio. On the floor a canvas picture of the house in question is spread and the man pursued just scrambles along it on his hands and knees.

The effect of inanimate objects moving themselves, such as coffee pots pouring themselves, chairs and similar objects jumping up in the air, chimney pots falling off and flying back into position, and typewriters working of their own accord, is produced by means of wires which are either too fine to appear in the picture or, if they show, are readily painted out.

Railroad collisions are frequent enough, one would imagine, to enable the moving picture concerns to obtain genuine pictures of them, but the thrilling pictures seen on the moving picture screen are obtained in a far less realistic manner. Miniature trains constructed and staged with great fidelity to actual conditions, and which run automatically, are used for the purpose, and serve very well. Sometimes an auto is made to collide at a crossing with a locomotive in a similar manner.

The familiar film showing a painter stencilling a ceiling, to which he appears to be clinging in a most unnatural manner, while an assistant is holding a pot of paint up to him, never fails to create wonderment among the uninitiated, but is easily made. The pictures are taken in a make-believe room, the walls of which are painted upside down on a four-sided screen, and the floor of which is painted white to resemble a ceiling. To a rafter across the top a man is suspended by his feet and holds an empty paint pot towards the floor, upon which the man posing as the painter kneels. The latter holds a stencil to the floor with one hand and with the other dips a brush in the paint pot which the suspended man holds towards him. After the pictures are taken the film is run off upside down and gives the topsy-turvy effect desired.

In a similar way the film which shows a man holding himself to the ceiling by the top of his head and the palms of his hands is made, the man simply standing on his head. To make the picture realistic, tables and chairs are attached to the make-believe room and an elaborate chandelier is attached to the floor, so that when the film is reversed the room will appear to be fully furnished and equipped.

In two out of three moving pictures there is a pursuit in which men, women and children are made to scamper over hill and dale at phenomenal speed, horses and wagons and automobiles tear pell-mell through the streets, knocking over fat policemen in their path, and everything moves with a hustle and bustle that is little short of amazing. It is needless to say that neither the animate nor the inanimate subjects of the pictures ever actually covered space at the rate indicated. When the pictures are taken, the persons posing for them may move as leisurely as they please, the effect of speed being produced by cutting out numerous sections of the film.

The super-imposed negative, a process familiar to every photographer, is often resorted to to produce weird effects. In this manner are made the films showing normal-sized men and women watching a contest between what appear to be men and women no bigger than a thumb. Two sets of pictures are taken. First, the full-sized spectators are photographed while making the gesticulations and motions to be expected of interested spectators, and then another set of pictures of the contestants is made, the persons posing for them being stationed at such a distance from the moving picture machine that they come out very small in the pictures. It is then a comparatively simple matter to combine the two films.

To construct a sky-scraper in the short space of a minute or two seems easy enough after observing the operation on the moving picture screen. The foundation is dug, the steel skeleton construction is completed, the masonry and woodwork are added, the scaffolding is removed and, lo and behold, the tenants are filing in and out, all within the space of time it takes to run off the film!

But to make the film is a much more tedious operation than might be supposed. Every day during the progress of the actual building of the structure the moving picture man must photograph the work, and when the building is completed pictures of the tenants going in and out must be taken. Then the various films are united, and the effect when they are run off on the screen is little short of marvellous.

The adventures of "Alice in Wonderland" have suggested some most fantastic ideas to the moving picture man. In one of the films Alice grows so large that she literally bursts through her house, her legs and arms bulging through the windows and walls.

This effect was obtained by means of the multiple process: separate, normal-sized pictures of the house being taken first, and then pictures of Alice with her arms and legs enlarged to such an extent that they fairly filled the window and doors. When the two films are combined Alice is prodigious enough to suit the most fastidious.

Most of the moving picture concerns employ regular stock companies, the members of which receive high salaries.

There are few moving pictures displayed in which some deception of this kind is not practised, but nobody minds it. When we go to the land of make-believe we are willing to be fooled.

No effort is spared to produce weird effects of this kind. Skilled actors are employed and elaborate properties constructed to make the pictures successful, and the moving picture man is always looking for something novel and unique.

### FITTING HINGES

(*Continued from page* 186)

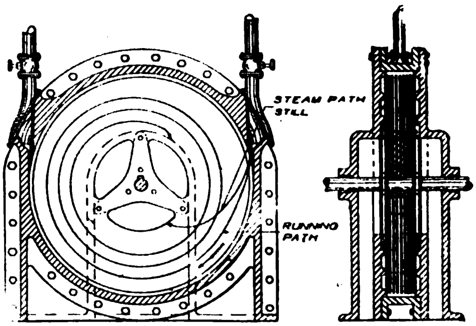
Doors are treated in the same way, the hinges being put on the door first, and then it is supported in position against the post for marking the height of the hinges, and, finally, for screwing them. The weight of the door is supported during these processes by packing it up with thin bits of wood or wedges beneath. The door should be turned back as far as possible, so that the hinges are wide open, as in the upper views in Figs. 7 and 8. There is then no difficulty in attaching it properly. In house doors an open joint is often allowed, so that the door will open reasonably wide, without binding against the moulding of the doorway. The open joint is not made by screwing the hinges on the surface, but by letting their knuckles stand out a little farther when the door is closed.

# THE SIMPLIFIED TURBINE

At the meeting of the National Electric Light Association, last spring, Nikola Tesla announced for the first time tests on an improved and simplified form of turbine prime mover which, from the success so far achieved and from the probabilities, seems to embody a long step forward in the utilization of the energy of steam. Two difficulties have handicapped the turbine, the complication in reversing, and the great number of small parts which must be assembled to make the complete machine. Effort has been expended on all classes of prime movers to secure simplicity, gradual abstraction of the energy of heat and high speed in order to reduce waste. If the development of the future bears out the present promise, the new form devised by Tesla will go far to remove all these difficulties, and secure desirabilities.

To give an idea of what he has accomplished, a small turbine having a rotating member 9¾ in. in diameter and 2 in. wide, developed 110 h.p. with free exhaust, and it had no blades, vanes, valves or sliding contacts of any kind, except the journal bearings. Furthermore, to reverse the direction of rotation, all that is necessary is to close one valve and open another. This power was developed when exhausting to the atmosphere and taking steam at 125 lbs., and another unit on which rather extended tests have been made, and which had a rotor 18 in. in diameter by 3½ in. wide, running under like conditions of pressure and exhaust has developed 200 h.p. at a steam consumption of 38 lbs. per horse-power hour. While this does not seem a very remarkable steam economy, it must be remembered that this is a first experimental engine, that the turbine form of prime mover does not operate with the best economy unless the exhaust is at low vacuum, and that the weight of engine per horse-power developed was only 2 lbs. The space occupied by this 200 h.p. unit is only 2 ft. x 3 ft. and 2 ft. high.

At first thought it might seem that the speed used, 9,000 revolutions per minute, would be a drawback; but here again it must be remembered that the rotating member consists only of thin steel discs fastened firmly to the shaft,




Sectional View of the Simplified Turbine

and having no blades, vanes, or other loose or attached parts, and that even at the highest speed the tensile strain is not over 50,000 lbs. per square inch on any part of the machine.

Tesla predicts that with a low-pressure stage added, exhausting into a 28½ or 29 in. vacuum, as is the case in steam turbine practice, he will secure a steam consumption of less than 12 lbs. per horse-power hour on a 200 h.p. unit, and that he will be able to get 10 h.p. per lb. weight of prime mover.

In accomplishing this result, Tesla has made use of a new principle in steam engineering, namely, the viscosity and adhesion of the fluid.

Heretofore, in abstracting the energy from steam, the reaction of steam to push the moving part forward has always been utilized. In the Tesla turbine the steam drags the rotating member around with it by means of the adhesion of the steam to surfaces of the thin discs.

A somewhat similar process in the reverse direction has been utilized in the water brake for testing turbines in which discs are revolved rapidly in a chamber filled with water and the drag of the water on the discs produces a braking effect which loads the turbine. In that application, however, the discs are kept at some considerable distance apart and usually blades are introduced between them to retard the water so that the friction of the disc on the water is depended on to produce the drag.

It is easy to conceive that by placing the blades close together the water which will be caught between them would be thrown out as in the case of a centrifugal pump, and if there were an inlet at the center, a centrifugal pumping action would be produced. This is exactly what Tesla has done in the pump application of his principle; and the motor application is simply a reversal forcing the steam in at the edge of the discs in a tangential direction and permitting it to work its way inward in a spiral path until it exhausts at the center of the disc.

In the 200 h.p. unit there are 25 discs, each 1/32 in. thick, and so placed on the shaft that the entire distance occupied along the shaft is 3½ in. As there are no guide plates or vanes, the steam takes its natural path from the circumference to the center, and when the rotor is at rest, it flows by a short-curved path, as indicated by the line in the end view, across the face of the disc. When the rotor is up to speed, the steam, in making its passage across the face of the disc, makes several revolutions, so that its path is from 12 to 16 ft. in the form of a spiral as indicated.

It is evident that as the direction of rotation of the shaft is determined entirely by the direction of the entering jet, all that is necessary to reverse the flow and the rotation is to shut off the nozzle at one side of the disc and turn on the nozzle at the other side. The drawing, which is an illustration of the patent principle, shows how this is accomplished, but does not, of course, indicate the actual detail of the working machine.

To show the reversibility of the operation as prime mover or pump, two 200 h.p. machines are coupled together through a torsion spring, and one of these is driven as a turbine while the other one has steam admitted in the direction opposite to that of rotation, and is used as a brake. Evidently the amount of twist of the torsion spring is an indication of the load carried and this has been used to construct a direct reading horse-power indicator which shows at a glance just what power is being developed.

Mr. Tesla, in an interview given to the *Electrical Review*, has stated that the 110 h.p. turbine has attained a performance of more than 2 h.p. per pound of material, and by careful construction for lightness might have been much improved, also that the steam consumption for this little unit was only 36 lbs. per horse-power hour with free exhaust and back pressure of 1 to 2 lbs. He states further that this economy could further be greatly increased by using a 2-stage machine, so that it would not take over 12 lbs. per horse-power hour, which will be recognized as a remarkable performance for a 110 h.p. prime mover.

To demonstrate the efficiency of the principle as a pump, Tesla has in his offices a 1/12 h.p. electric motor driving a Tesla pump, which pumps 40 gal. a minute against a 9 ft. head. Evidently the motor is carrying some over load, as the water horse-power would be 0.09, while the rated capacity of the motor is 0.083 h.p., but the demonstration serves to show the high efficiency of the principle when applied to pumping.

It is evident that so simple a device, and one which has in it the elements of high efficiency, has wide application in the industries, and, the simplicity of construction and the strength that may be secured, make it seem probable that a solution of the gas turbine proposition is to be worked out along this line. It is quite conceivable that by applying this method the simplicity of the steam turbine and the high efficiency of the gas engine will be combined, giving us a more efficient heat motor than has yet been known. Much remains to be determined as to distance between discs, diameters and speed of revolution for different pressures, but the workability of the principle seems to be proved.—*Practical Engineer*.

### X-Ray Apparatus of Today

(*Continued from page* 161)

volts are required to jump them, and this is, of course, wasted energy.

The results attained with this extraordinary arrangement, as regards the resultant wave form, is seen in Fig. 8, as contrasted with the wave-form of the secondary current supplied by an induction coil, Fig. 9. As will be evident, there are dead intervals between each pulsation of direct current as supplied by the "Interrupterless" outfit, but the current does not fall as rapidly in value as the induction coil current, and there is no inverse current, whatever, to injure and disintegrate electrodes of the X-ray tube.

This type of machine gives extremely good results in connection with a high-frequency therapeutic or treatment set, the regular connections being given in Fig. 10 and 11 for Tesla coils and Oudin coils, respectively.

# CONCRETE AND CEMENT

P. LEROY FLANSBURG AND L. BONVOULOIR

One of the most important materials used in the building construction of today is concrete. This material and its method of use are by no means new and date back to the Romans more than 2,000 years ago. In 500 B.C. the Romans made use of concrete and secured most excellent results from a mixture of slaked lime, volcanic dust, sand and broken stone.

The Romans used concrete for many purposes, such as pavements, floors, walls, arches and domes. Almost invariably the Roman walls were built of concrete, faced with brick, stone or marble, the facing being very thin. Really, the concrete was employed as a core between the inner and outer facings. An example of early concrete construction is the Pantheon in Rome which was built by Agrippa about the time of Christ. The dome of this building is 142 ft. in diameter, and is built of concrete in a framework of brick arches. To construct a similar dome would be regarded as an engineering feat even at the present time. The development of domed structures among the Romans was probably in a large measure due to the use of concrete. Other examples of early concrete construction are the aqueduct of Vejus and an upper floor in the House of Vestals. This floor has a span of 20 ft. and is 14 in. thick. In the Baths of Caracalla there are remains of extensive concrete vaults.

The Normans well understood the use and value of concrete and it was extensively used by them for walls and foundations. It is an interesting fact that the castle of Badajos in Spain still shows the marks of the boarded frame into which the concrete was poured. In many of the Norman and English cathedrals, concrete was successfully employed in the foundations, some of the best examples being Ely Cathedral, Westminster Abbey, and Salisbury Cathedral. During the latter half of the twelfth century, Guilford castle was erected with concrete walls, 12 to 14 ft. thick at the base.

The concrete of today is a mixture of lime or cement, water, sand and small irregular pieces of stone, brick, cinders, etc., and differs from that of the Romans only in that cement is usually employed in place of the lime. The ingredients of concrete may be divided into two classes: the first being the active or cementing materials, namely, lime or cement and water; the second, the inactive materials such as sand, small pieces of stone, brick and cinders. The active agents which cause the concrete to solidify are termed the matrix, while the inactive ingredients are called the aggregate. Since the aggregates are of irregular shape and varying sizes, there would ordinarily exist air spaces between the separate pieces, and it is the duty of the matrix to fill all such spaces (which are known as voids) and form the whole into a solid mass.

While we have seen that concrete has been used for over 2,000 years for building purposes, it was not until the invention of "Portland cement" by Joseph Aspdin of Leeds, England, that concrete assumed a foremost place in the list of available building materials. The cement was discovered by Aspdin in 1824, and is without doubt the strongest cement that the world has ever known. For the next twenty-five years progress was slow, but about 1850, due to both improved methods of manufacture and improved quality of the finished product, there was a more general recognition of its merits and its commercial success was assured.

Until quite recently, lime was practically the only material employed as a matrix. The Romans made use of lime for all of their construction work, both for concrete and mortar, and good evidence is shown of how well they understood its nature by such of their structures as still exist. When lime is used as a matrix, it should be ground, not slaked and sieved, as is done in some places. There are conflicting opinions as to whether it should be used fresh or allowed to season.

Probably the inventor of Portland cement never for a moment imagined what a revolution it would make in all building and engineering works. The Thames River tunnel was the first engineering work of importance in which Portland cement was used. Originally, chemistry had little or nothing to do with the manufacture of Portland cement, and, as a result, the original cement was a weak product compared with that of today.

An average analysis of some of the best modern cements is as follows:

Lime, 60 to 65 percent; silica, 20 to 25 percent; alumina, 6 to 9 percent; oxide of iron, 2 to 5 percent; sulphuric acid, 1 to 4 percent; magnesia, 1 to 3 percent.

The magnesia is simply an impurity in the chalk and it may cause expansion and disintegration if it exists to a greater extent than 1 to 3 percent. Nearly all governments limit the presence of this impurity to 4 percent in the finished product.

Repeated experiments have shown the importance of uniform fineness in cement, and that it cannot be ground too

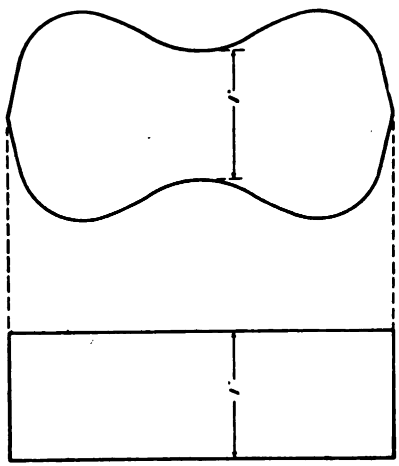


Fig.1.

finely or sifted too carefully, since its tensile strength is dependent upon its fineness, when mixed with sand. Also, the finer the cement, the greater is its adhesive strength. Two different sieves are used to test the fineness: one of 100 meshes to the inch (10,000 to the square inch), and the other of 200 meshes to the inch (40,000 to the square inch). The cement is first passed through the 100-mesh sieve until not more than 1 percent passes through after sifting one minute. The sieve is moved back and forth at the rate of about 200 strokes per minute, tapping at the same time with the other hand. The part remaining in the sieve is then passed through the 200-mesh sieve in the same manner.

In order that the tests made shall be the same everywhere and that the manufacturers may have a definite standard to work from, the American Society for Testing Materials has issued a pamphlet containing standard specifications for cement. These specifications are used when any concrete construction work is being carried on. The following extracts are taken from the pamphlet: "Portland Cement is the term applied to the finely pulverized product resulting from the calcination to incipient fusion of an intimate mixture of properly proportioned argillaceous and calcareous materials, and to which no addition greater than 3 percent has been made subsequent to calcination. The specific gravity shall not be less than 3.10. Its fineness shall be such that it shall leave by weight a residue of not more than 8 percent on the No. 100, and not more than 25 percent on the No. 200 sieve. It shall not develop initial set in less than thirty minutes; and must develop hard set in not less than one hour, nor more than ten hours. The minimum requirements for tensile strength for briquettes 1 sq. in. in section shall be as follows:

| Age | Neat Cement | Strength |
|---|---|---|
| 24 hours in moist air | | 175 lbs. |
| 7 days(1 day in moist air, 6 days in water) | | 500 lbs. |
| 28 days(" " " " " 27 " " " ) | | 600 lbs. |

The cement shall contain not more than 1.75 percent of anhydrous sulphuric acid ($SO_3$), nor more than 4 percent of magnesia (MgO)."

It is, of course, desirable to test every new batch of cement to see that it comes up to the specifications, as different batches are apt to vary somewhat in quality, or may have become damp in transit and have had its quality impaired thereby. In order to obtain a representative value of the batch, a small quantity of cement is taken from a certain number of barrels, say one in every ten. A hole is drilled in the side of the barrel, and the cement so obtained is mixed thoroughly. The results of the tests are taken as the average value of the batch.

The most important test is the tension test. Briquettes of the shape shown in the sketch, Fig. 1, and having their smallest cross-section of 1 sq. in., are made either neat or in the ratio 1 to 1 (one part of cement to one part of sand). After being carefully tamped in the molds

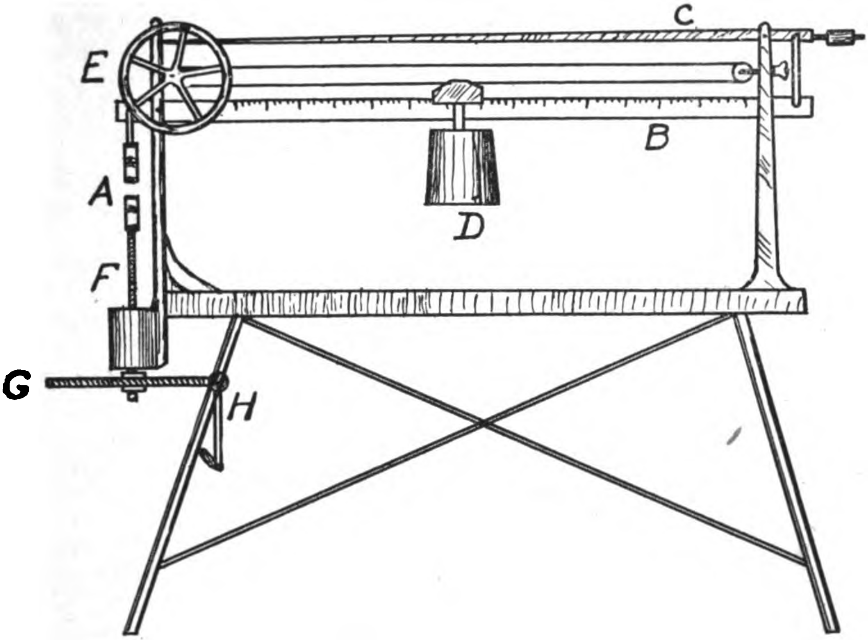



Fig. 2. Machine for Testing Briquettes

they are allowed to set for one day in moist air and then placed in water for periods varying from one day to 28 days. Several different types of machines are used to test the briquettes, but in principle they are all alike. The machine shown in Fig. 2 is one of the common types. The briquettes are placed in the jaws marked *A*. The upper jaw is connected to a system of levers *B* and *C*. *D* is a weight mounted upon a roller and travels on *B*. It is propelled by means of a cord running over pulleys and to one of the pulleys is attached the handwheel *E*. The end of the lever *C* comes opposite a small fixed pointer and is used merely to magnify the deflection and thus make possible a more perfect balance. When a briquette in *A* is under tension, *C* drops and by turning the handwheel *E*, the weight is moved until balance is secured and the end of the lever *C* comes directly opposite the pointer. The tension may then be read on *B*, which is graduated in pounds. The lower jaw is attached to a long screw *F*, which passes through a nut in the center of the gear *G*. *H* is a worm engaging in *G* and turned by a handle. When a briquette is being tested, *H* and *E* are turned at the same time, thus applying the load with one hand and keeping it balanced with the other until the briquette breaks. The breaking strength per square inch may then be read directly from the scale.

Compression tests are rarely made outside of the laboratory, since the crushing strength of cement is much greater than its tensile strength, and therefore such tests would require heavier and more expensive machines. It is true that concrete or cement is rarely used in tension, but since the results are merely comparative and have no relation to their actual strength when in use, the results obtained from the tensile tests are the only ones needed.

Next, in importance, comes the time of setting. Two sets are recognized: the initial and the final sets. A Vicat needle is usually employed to determine the time of set, but home-made needles may be used with as good results. In Fig. 3 a wire or rod 1 mm. in diameter is fastened to a weight so that their combined weights shall be 300 grams. A screw permits raising or lowering the weight. A pat of cement is placed and the needle is carefully brought down to the level of the pat. When the needle no longer penetrates to a point .2 of an inch above the glass plate, initial set is said to have been obtained, and when it no longer sinks into the surface, final set is reached.

The other tests described in the speci-

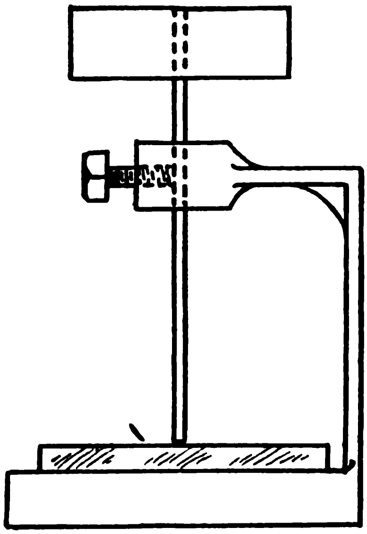


Fig. 3

fications of the American Society of Civil Engineers are not usually made in the field, since they require somewhat elaborate apparatus.

A matter of great importance is the testing of the voids in the sand and aggregates to see that with the given proportions, all of the voids will be filled. The following is the method usually followed. A water-tight vessel of known volume is filled up level with the aggregates, and water is poured in until it comes level with the top, taking care to notice the amount of water poured in. This volume of water divided by the volume of the vessel will give the proportion of voids in the aggregates. The voids in the sand are measured in the same way. Suppose we have a 1:2:4 mixture. The vessel contains 1,000 cu. in., and 400 cu. in. of water have been poured in after it was filled with the aggregates. Then there are 40 percent of voids in the aggregates. From the proportion of 1:2:4 it is seen that 1,000 cu. in. of aggregates would be used with 500 cu. in. of sand and 250 cu. in. of cement. 40 percent of voids would require only 400 cu. in. of sand, so that we have an excess of 100 cu. in., and we are certain that all of the voids are filled. If the voids in the sand are found to be 35 percent and 250 cu. in. of cement are to be used with 500 cu. in. of sand the proportions would be correct. True, this would give us an excess of cement, but this is desirable, as we must allow for shrinkage of the cement and sand when mixed with water.

In measuring the sand care should be taken thoroughly to dry it as there is always some moisture present in the sand, and this would cause the voids to appear to be smaller than they really are. In case the voids in the aggregates exceed the amount of sand to be used, the aggregates should be broken up into smaller sizes or else a different kind used.

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## Aeroplanes in the Postal Service

With the aeroplane's practical military value being so clearly demonstrated before our very eyes, we only need to turn our attention in another direction to see an even greater practical triumph accomplished by the aeroplane for another branch of the Government which means no less for the immediate progress of our rapidly moving civilization in time of peace than the wonderful accomplishments of the aeroplane toward the practical solution of some of the great problems of war. I refer to the recent establishment at Allahabad in India of an aerial postal service with special aerial postmarks to be put upon all letters, and a complete postal installation embracing all the red tape attached to the transportation of His Majesty's "Royal Mail." This has lately been done under the personal supervision of Captain W. Windham, who organized this excellent undertaking to demonstrate the absolute practicability of maintaining postal communication with a city, even though it may be undergoing a state of siege and is completely surrounded by the forces of the enemy. Over six thousand letters were carried in specially-constructed mail pouches which were carefully loaded upon an aeroplane and transported to a neighboring postal station.—*Augustus Post on "Practical Uses of the Aeroplane" in June Columbian.*

---

*Prisoner* (stuttering painfully): "Tz-tz-tz-st-st-st!"

*Magistrate:* "Dear, dear, what's he charged with, Constable?"

*Constable:* "Sounds like soda water, your worship.—*Everybody's Weekly.*"

# WIRELESS TELEGRAPHY

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

## THE USE OF ALUMINUM WIRE FOR AERIALS

CHAS. HORTON

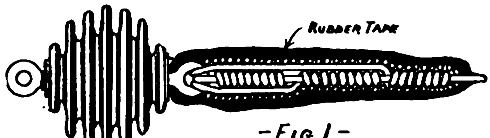
Wireless men as a rule discourage the use of aluminum wire for aerials, on the ground that it is too apt to break under strain, and that good connections cannot be had, because it cannot be easily soldered. The use of copper wire eliminates these troubles, but, as copper is much more expensive than aluminum, length for length, it would be very desirable, if possible, to use aluminum, especially for amateurs.

The author's experiences in the use of aluminum for aerial construction shows that this wire may be so used and with very good results, if proper precautions are taken.

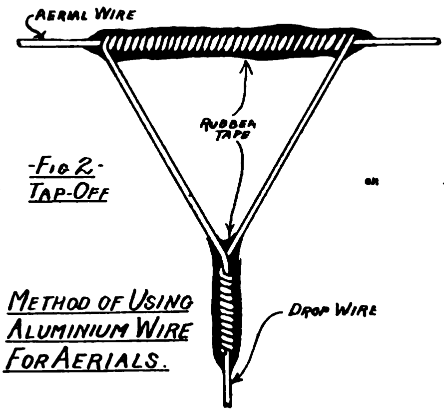
The author has such an aerial of four No. 12 aluminum wires, which span a distance of almost 200 ft. The wires are almost 4 ft. apart and about 80 ft. from the ground where the station is located. This aerial has been in use about a year, and has weathered some very severe storms, including the hurricane that we had early in the spring. One thing in favor of aluminum wire is the fact that, owing to its somewhat oily surface when oxidized, it does not allow the formation of ice in sleety weather, thus eliminating one of the causes which break down many telegraph and telephone lines every winter.

Now, as to the methods to be used, and the precautions to be observed:

1. In order to prevent galvanic action, which is very apt to occur with aluminum, see that all contacts of the aluminum with any other metal be prevented as far as possible. For instance, where the wire loops through the galvanized ring of the insulators, the ring should be first wound with tape and then the wire looped in and fastened so that the tape prevents any electrical connection with the zinc.




-Fig 1-
Connection To Insulator




-Fig 2-
Tap-Off

Method of Using Aluminium Wire For Aerials.

2. All joints should be soldered with special aluminum solder on the market, or if this is too difficult, the wires may be scraped clean and wound together tightly for a distance of 3 or 4 in. The finished joint is then wound over tightly with rubber (Okonite) tape which soon forms a water-tight one-piece coating and effectually protects the wire from oxidation. The author, on examining such a joint after a hard season, saw that the surface of the wire was perfectly bright. The rubber may be protected by a layer of ordinary tape.

3. Where the wire is sharply bent or

subject to strain, it should be reinforced as follows:

The wire is first looped through the taped insulator ring and twisted about itself as usual. Referring to Fig. 1, the aerial wire is shown in the middle passing through the ring and twisted about itself close up to the insulator ring. Next, a piece of aerial wire is looped through the ring and each end twisted about the aerial wire beyond the first twist. This is readily seen in the drawing. Now a long piece of aerial wire is very tightly wound over the whole and fastened in the insulator ring on one end and twisted about the aerial wire at the other. This winding is shown in section in the drawing by the two rows of circles. To finish, the whole joint is wound tightly with rubber tape, and, if desired, the rubber wound with ordinary tape. The rubber tape is here shown in section by the heavy black part. Soon after the rubber tape is wound on, it becomes a solid piece of rubber, and it is impossible to unwind it again. When it is cut off for inspection the joint will be found perfectly bright.

4. The aerial here referred to is of the shifted T-type, and where the drop wires are taken off the joint is made as follows. Referring to Fig. 2 it will be seen that the drop wire is brought to the aerial wire, wound about for a distance of 3 or 4 in., and finally brought back and twisted about itself, thus forming an open triangle. This form of joint prevents a right-angled connection, which would sway back and forth until the wire breaks off.

5. When using pincers to twist the wire, be very careful that the cutting edge does not nick the wire, for even a slight nick is apt to cause a break.

If all the points given above are carefully observed, no trouble will be experienced. No. 10 or 12 should be used unless the span is very short, when No. 14 may be safely used.

## IMPROVED MINERAL DETECTOR STAND

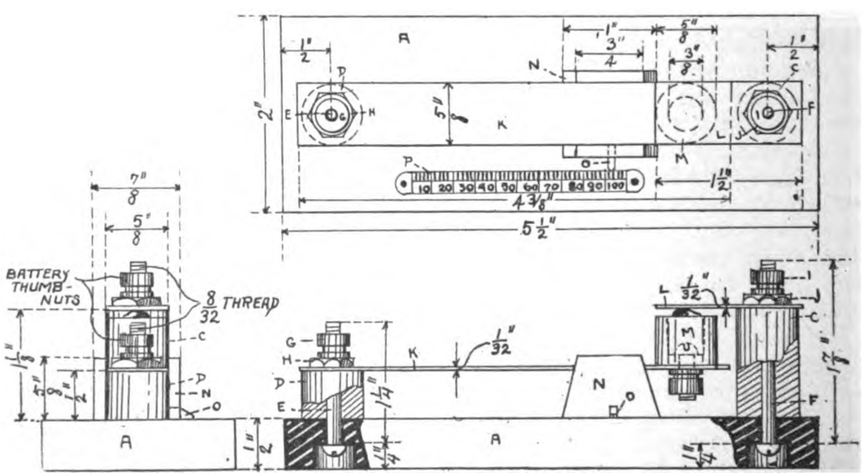
P. MERTZ

A mineral detector stand that has been designed to eliminate several disadvantages of the ordinary type, and yet be as simple, compact and efficient as possible, is shown in the illustration.

To make this detector get a base *A*, preferably of hard rubber, 5½ in. long, 2 in. wide and ½ in. thick. Then drill two 11/64 in. holes in the positions shown at *E* and *F* in the plan view, and counterbore them on the under side with a ⅜ in. drill to a depth of ¼ in.

Get two pieces of brass tubing (*C* and *D*) ⅝ in. outside diameter, 11/64 in. inside diameter, and 1⅛ in. and ½ in. long, respectively. As this tubing is hard to get and is expensive, thin tubing can be used if filled with melted solder or lead,

IMPROVED MINERAL DETECTOR STAND.



while an 11/64 in. bar is held in the center of it, forming a core, which is removed when the solder is hard.

Procure two 8-32 round head brass machine screws *E* and *F*, respectively 1¼ and 1⅞ in. long, with two thumb and hexagon nuts *G* and *H*, *I* and *J*, to fit each.

Get two pieces of spring brass or phosphor-bronze strips *K* and *L*, ⅝ in. wide, 1/32 in. thick, and 4⅜ and 1½ in. long, respectively, with a 3/16 in. hole drilled ⅜ in. from one end of *L*, and each end of *K*.

Also obtain a piece of brass rod *M*, ⅝ in. in diameter and ½ in. long, with an 11/64 in. hole drilled right through and counterbored with a ⅜ in. drill, to a depth of ⅜ in. Pass an 8-32 round head brass machine screw ½ in. long through the small hole, as shown in the illustration, and fasten the sensitive crystal in the cup in the usual manner. You can now pass the screw through one of the holes in K and fasten the cup to the spring with a battery thumb-nut.

When this has been done the screw *E* may be put through its hole in the base *A*, and the brass tube *D* and brass strip *K* are slipped over it. Then the nut *H* is screwed over this and *G* put on to act as binding-post. The same is done with screw *F*, tube *C*, strip *L* and nuts *J* and *I*, on the opposite side of the base.

Now the slider *N* can be made. This is cut out of a piece of hard rubber or black fiber 1 in. long, ⅞ in. wide, and ⅝ in. thick to the shape shown, not forgetting the saw kerf to admit the indicator *O*. This indicator consists of a piece of 1/16 in. sheet brass cut out as shown and forced into the kerf made in *N*.

A scale *P* is now to be made of thin sheet brass and divided into 100 parts, as shown.

Then the slider *N* is placed in the position shown in the illustration and the springs *K* and *L* bent so that when *N* is at the extreme left (*O* on the scale) the crystal in cup *M* will not touch *L*. When, however, *N* is brought to the right, different degrees of pressure can be brought upon the mineral according to the number shown on the scale by the indicator.

When the contact between *L* and the crystal in *M* is to be broken for sending, or for any other reason, the number shown by the indicator must be noted, and the slider pushed to the extreme left *O*.

When contact is to be restored, *N* is simply pushed to the right until the desired number is shown by the indicator.

## NEWS OF THE WIRELESS SOCIETIES

### The Massachusetts Institute of Technology Wireless Society

The Mass. Institute of Technology Wireless Society.—In response to the request for names to aid in the compilation of a directory of wireless amateurs near Boston, as published in the January, 1912, *Electrician and Mechanic*, a considerable number of letters have been received by the Secretary.

It will be of great advantage to Boston amateurs if a complete and accurate list of their stations can be compiled and published; and it is sincerely to be desired that every amateur who possesses a station powerful enough to communicate readily with Boston should send in to the Secretary his name, address, call letters and power. It will also be appreciated by the Society if he will send in the same information about other amateur stations which he knows to be in constant operation.

It has already become impossible to answer all the letters which have been received; but notice will be given when the list is ready for publication, and operators whose names appear in it will be given a chance to secure copies at cost price.

J. H. ELLIS, *Secretary.*

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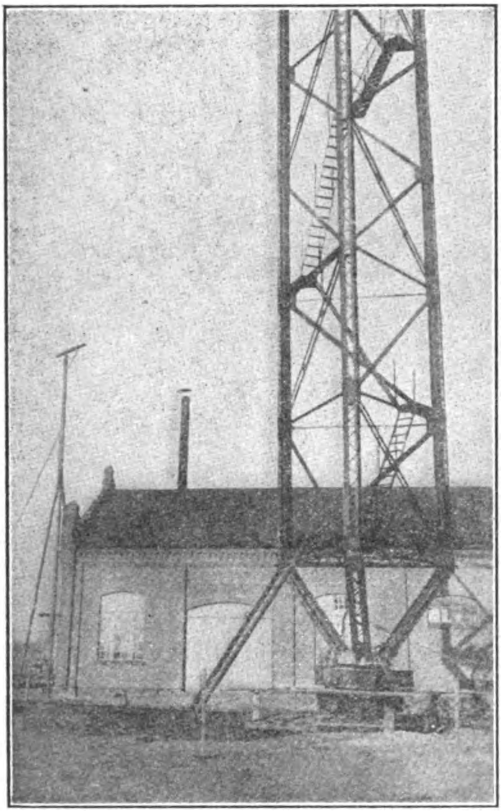
Pittsburg, Pa.—The Signal Corps of the National Guard of Pennsylvania, with headquarters in Pittsburg, will be equipped with two complete United States Army type portable wireless outfits. The issue of the equipment will be made about February 1, and wireless practice stations will be installed immediately.

The armory of the Signal Corps is located on Mt. Washington, south of the city, more than 400 ft. above the surrounding valleys and overlooking the business district. The other stations



The Foot of the Tower

will be placed at other points in the city, and the signalmen will be taught thoroughly in the uses and technical operation of wireless telegraphy. The system will be the same in use on government vessels and in the United States army.

Practice hikes, the transmission of messages and field maneuvers with the cavalry and infantry organizations of the Pennsylvania Guard have been planned, and in consequence there has been a rush for enlistment in the Signal Corps. Among the applicants are many men among the workmen and electrical engineers connected with the big local Westinghouse plants. Capt. Frederick C. Miller of the Signal Corps says he has a big waiting list of applicants and so great has become the enthusiasm for the service that the organization of another company has been suggested.

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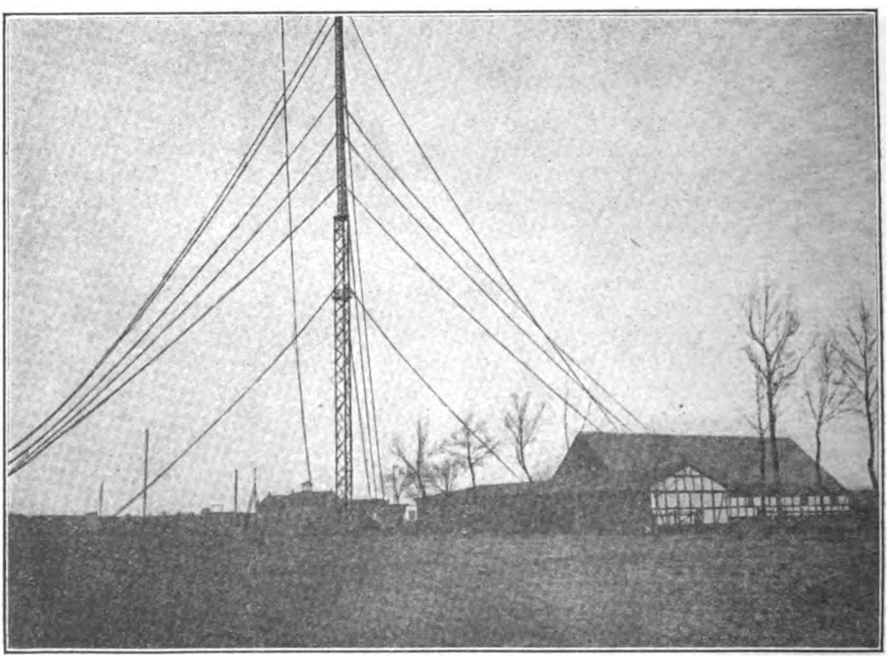
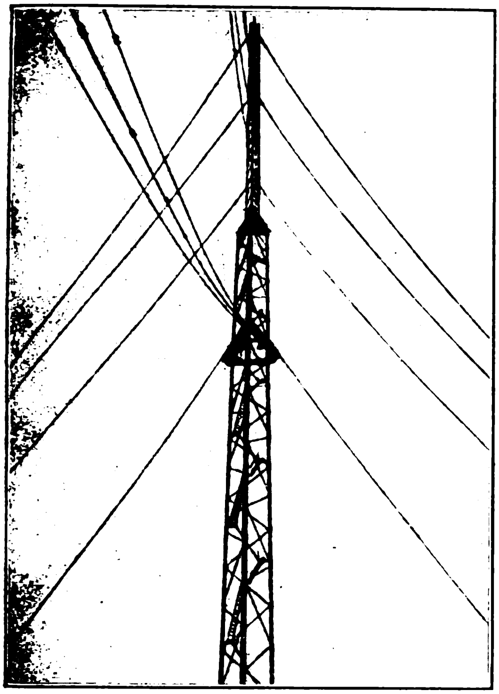
The first meeting of the fourth year of the Chicago Wireless Association's career was held on Friday, January 12, 1912, at the club room in the Athenaeum Building, Chicago, Ill.

The following officers began their duties at this meeting: John Walters, Jr., *President;* E. J. Stion, *Vice-president;* C. Stone, *Treasurer;* F. Northland,

(*Continued on page* 208)



General View of the Highest Station in the World



Addition Made Above the Triangle

## The Highest Wireless Station on Earth

FELIX J. KOCH

One of the most wonderful achievements in mechanical engineering has been completed lately at Reinickendorf in Berlin. The most striking feature of this wireless station is the 200 meter high mast (about 660 ft.). It was only 330 ft. recently, when, just lately, another 330 ft. has been added. Except for the Eiffel tower in Paris, this station is the highest in the world. Owing to the fact that the power of the machine has been increased four times, this station can communicate with all stations within a range of 6,000 (nearly 4,000 miles) k.m., so that Germany can get easily in touch with all its possessions.

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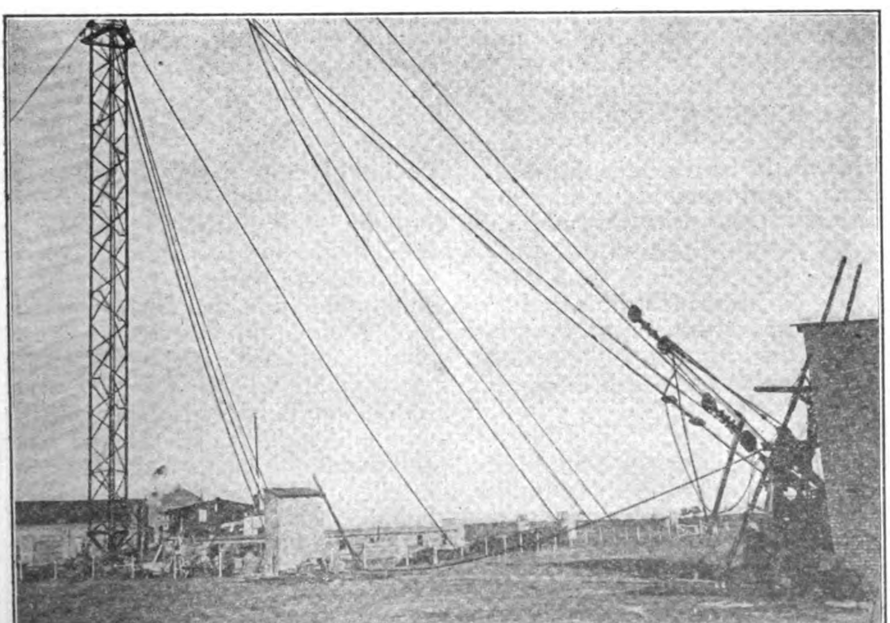
## Play Full Game of Checkers by Wireless

A checker game by wireless, the first on record, was played at Minneapolis, Minn., recently, between C. L. Holton and James A. Coles. The distance between the homes of the contestants is two miles. From the time the game was declared on until Mr. Holton took Mr. Coles' last man, the players were in almost continuous communication.



A Steel Cable Anchoring

## News of the Wireless Societies

(*Continued from page* 206)

*Recording Secretary;* R. P. Bradley, 4418 S. Wabash Ave., Chicago, Ill., *Corresponding Secretary.*

The Association will be pleased to correspond with any wireless club in the country. All communications should be addressed to the Corresponding Secretary.

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The Tufts Wireless Society gratefully acknowledges the receipt of copies of the January number of *Electrician and Mechanic*, and sends its appreciation of the notice concerning the society. The station is now working, and we should be very glad to entertain anyone you care to send out.

J. A. PRENTISS, *Secretary.*
3 East Hall, Tufts College.

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The Wireless Association of Canada, 189 Harvard Ave., N.D.G., Montreal, Que., Canada, has been organized for the sole object of furthering the interests of amateur wireless telegraphy. Officers: Wm. C. Schnur, *President* and *Corresponding Secretary;* Thomas Hodgeson, *Financial Secretary.* For further information inquire by letter to above address.

WM. SCHNUR, *Corresponding Secretary.*

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## SPITZBERGEN'S WIRELESS STATION

The Norwegians are making the experiment of maintaining a wireless station at Green Harbor, Spitzbergen. Six men are stationed there, and for half of the year they will be cut off from the rest of the world. Dr. Sigel Roush of Troy gives the following account of the station:

"Strangely incongruous was the upstretching iron arm of this wireless telegraph station, as it gradually, foot by foot, arose, pointing to the sky. It is a Norwegian government project, and when completed will constitute one of the most powerful wireless stations in the world.

"The promoters hope by means of this 300 ft. tower and powerful batteries to be able to span the Arctic and touch by the waves of the atmosphere the ear of the listening instrument on the mainland.

"The great steel tower was braced by scores of metal guys, which were fastened to anchor pins deep-driven into the earth, for the winter winds even in the sheltered cove of Green Harbor are supposed to be terrific. Alongside the tower, and nearly completed, stood the combination office, living and battery house.

"This building was a marvel of construction, exhibiting walls more than 3 ft. thick, composed in order of timber, tar paper, felt and asbestos. Over the roof and around each of the four corners heavy iron cables were passed and made fast, after which they extended to the ground and were anchored in buried foundations of rock and cement.

"Thus every precaution was taken in constructing this desolate habitation to defy the cold and the winds, while in the cellar underneath sufficient food was stored to maintain those six polar prisoners through the weary length of the dismal night.

The government's excuse for such an expensive experiment is found in the explanation of the overseer. Said he:

"'First and most important of all is the value the station is hoped to prove in predicting those severe northern storms that, especially in winter, sweep unheralded down the Norwegian coast and work tremendous damage to Norway's shipping. Our fishing, is done mainly in winter, and thousands of fishing craft frequent the western coast to follow the one means of support to vast numbers of our people. If by means ofthis Arctic station we can give due warning of a destructive storm, the government, if for no other reason, would be justified in the investment.

"'Then again, the Norwegians have always been among foremost polar explorers. By means of this wireless station polar parties equipped with their own outfit can be traced and watched, and in case of danger can be located and reached. Greater risks can therefore be taken, and greater results be obtained.

"'Then, there is the commercial phase of the subject, for coal of a fine quality has been found in Spitzbergen, and even now an American-Norwegian company is mining coal here and shipping it to the Continent at a handsome profit.'"

# EDITORIAL

It is with a feeling of deep regret and personal loss that we find ourselves obliged to chronicle the unexpected death of Mr. William C. Getz, well known as a wireless expert. Mr. Getz had been ordered to the Philippines to take part in the erection of government wireless stations there, but was taken ill just after the transport left the Hawaiian Islands. Upon arrival at Manila he was so ill that the hospital authorities ordered his return to the United States. He grew steadily worse on the return trip and died in San Francisco on the 13th of January, 1912, a few days after landing. Mr. Getz leaves a widow and an infant daughter, to whom we are sure the sympathies of our readers will go out.

Although Mr. Getz would not have attained his twenty-fifth year until March 10th, he was an expert electrician and an authority on wireless installations. His early life was spent in Baltimore, and he began experimenting with wireless telegraphy among the earliest of the American amateurs. Becoming proficient in the days of needle detectors, he began manufacturing apparatus for sale to amateur friends and evolved a complete series of improved, tuned circuit instruments. These instruments he described for *Electrician and Mechanic's* readers in a series of articles which were the first published for amateurs on the subject of tuned circuit instruments. From the publication of this series dates the wide-spread interest of amateurs in wireless in the United States, and subsequent writers, as well as many builders of apparatus, have found a mine of information in these articles. Through their publication the attention of the United States Signal Service was called to his achievements and he was asked to enter the government's employ. This rendered it necessary for him to dispose of his rapidly-growing electrical instrument business, and as a signal service operator he traversed the entire United States, erecting and testing stations for the government, and it was in pursuance of his duty in this direction that he started on the trip which ended fatally.

Personally Mr. Getz was modest and unassuming, and in spite of his manifold duties his knowledge and time were always freely at the command of every earnest seeker after information.

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### Electricity's Part in Photography

The primary element of photography is light, either the bright, penetrating light of day or the intense artificial light of the electric arc. But aside from the boon of artificial light, electricity is a wonderful help to photography. During the rush seasons it is often necessary for a good photographer to work night and day to keep up with his orders. In this case, of course, all the night photos are made under the rays of powerful electric lights. But the simple taking of negatives is only the beginning of the artist's hard work. The plates have to be developed, dried, retouched and reprinted. Where there is time enough and to spare, the negatives are merely racked up and allowed to stand until they are dry. Often it is desirable to print up the orders quickly; and in such cases electricity is brought in to dry the plates. A simple way to effect this is to let the breeze from an electric fan play over the negatives, and other photographers have used to good advantage the electric hair dryers. This is a device combining an electric air heater and a small fan. This steady current of dry, hot air, will speedily dry the wet plates and prepare them for quick printing. An electric light is also used by the retoucher to bring out the detail of the negative. The printing itself can be done just as well and with a great deal more certainty beneath the rays of large arc lamps. Again the electric fan or the hair dryer is used, when rush orders are demanded, to dry the developed prints, and a small electric flat-iron is used to smooth out the prints in place of the regular press.

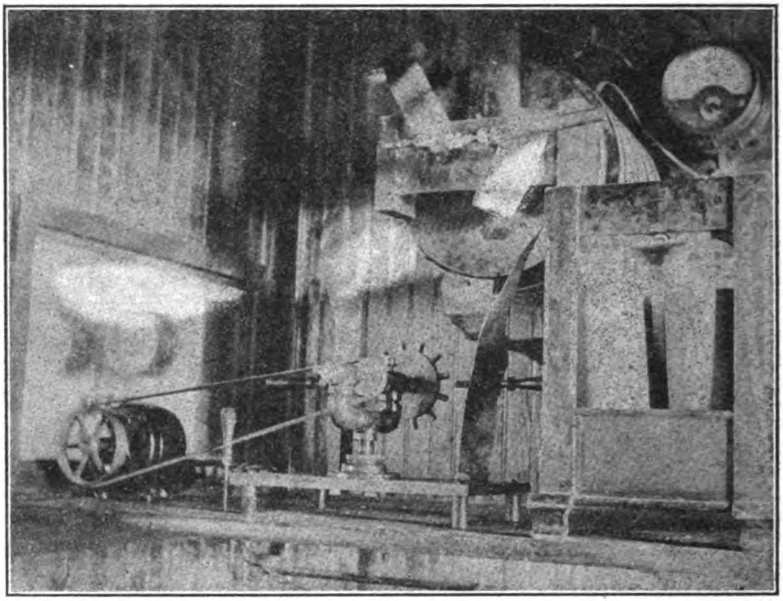


Photo Wireless Station by Getz

Transmitting side of the United Wireless Co.'s station at Hill Crest, San Francisco, which recently worked with a station in Japan.

We print herewith a bill of materials which, through an accident on the part of our printer, was omitted from the February issue, it being a necessary part of the article entitled "A 100-Watt Step-Down Transformer." In the meantime we have discovered that the major part of this article had been published in an earlier issue, by *Modern Electrics*. This we find was due to the fact that the author had submitted nearly identical articles to both publications, and in our case the type matter has been standing for some months. The bill of material follows:

BILL OF MATERIAL

| | Name | Material | No. Req. | Remarks, Sizes, etc. |
|---|---|---|---|---|
| No. 1 | Core leg | Soft sheet iron | | Enough to make a pile 2½ in. high |
| No. 2 | Core yoke | Soft sheet iron | | Enough to make a pile 2½ in. high |
| No. 3 | Spool tube | Hard fiber 1/16 in. | 2 | Bend into a square tube, 1¼ in. inside |
| No. 4 | Spool end | Hard fiber, ⅛ in. | 4 | Put 1 on each end of spool tubes |
| No. 5 | Insulator | Hard fiber, 1/64 in. | 2 | Bend into a square tube, 1¾ in. inside |
| No. 6 | Clamp-bar | Hard wood | 4 | |
| No. 7 | Bolt | M. steel | 4 | Standard 5/16 x 4 in. square-headed bolt |
| No. 8 | Base | Wood | 1 | Make to suit requirements |
| No. 9 | Washer | Copper | 8 | For bolts No. 7 |
| No. 10 | Wire | Copper | | 570 ft. No. 20 B.&S. d.c.c. for primary |
| No. 11 | Wire | Copper | | 77 ft. No. 10 B.&S. d.c.c. for secondary |

100-WATT STEP-DOWN TRANSFORMER

| | |
|---|---|
| Primary voltage, 100–110 | Primary turns, 980 |
| Secondary Voltage, 10–11 | Secondary turns, 100 |
| Frequency, 60 cycles | Weight, about 12 lbs. |

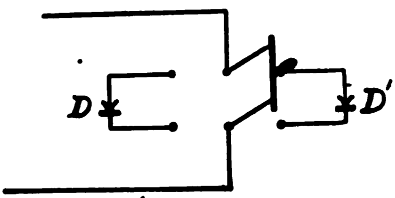
# QUESTIONS AND ANSWERS

**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.**

1730. **Detector Connections.** C. A., New Rochelle, N.Y., asks: How can I connect two mineral detectors so that I can receive a message on one and then switch off on the other detector and receive the same message? Ans.—By the use of a two-point switch with its arm connected to the instruments in place of one of the detector




D.D'= detectors

terminals. One terminal of each detector would be connected to the respective switch points, while the remaining detector terminals are bridged with a piece of wire which is in turn connected to the instruments in the usual manner as per diagram herewith.

1731. **Loose-coupled Transformer.** X. Y. Z., Springfield, Ill., asks: (1) Is a coil with a vibrator ever called a make-and-break coil; if not, what is? (2) Would like to have data for making a protection device to use in the primary of a wireless transformer. (3) I have a tuning coil 3½ in. in diameter, 14 in. long (double slide), 100 ft. aerial, 150 ft. high, composed of four aluminum wires spaced 3 ft. apart; 2,000 ohms Holtzer-Cabot receivers, Clapp-Eastham ferron detector and condensers. I can hear amateurs all over this city, but cannot hear any station such as a commercial out of town. Do I need a loose-coupler, or what? All joints soldered, etc. Ans.—(1) Yes, but not usually. (2) If you mean to protect the primary of a wireless sending transformer, a fuse is the proper thing; but if you mean a receiving transformer, use a lightning arrester. (3) Your apparatus is all right for local work, but your longer-distance receiving would be much improved if you would use a good loose-coupled transformer.

1732. **Induction Coil.** D. W. D., Montrose, Col., asks: (1) What is the rating of this coil in watts: Core 1 x 9 in., primary two layers of 12 d.c.c., secondary 6 lbs. of No. 30 enameled, to be run on 110 volts, if it was made a closed-core transformer? (2) How big a primary condenser should be used? A secondary shunted around spark gap? (3) How big and thick a spark should this coil give? (4) Where can I purchase a good set of wireless instruments for receiving? Ans.—(1) It is very difficult to give the voltage of your coil, either as open-core induction coil or closed-core transformer. Perhaps the output in the first case would be 1-12 k.w., and in the second about double this. (2) As an induction coil your primary condenser should have a capacity of about 1 or 2 m.f., the exact amount not being very important. A secondary condenser is always needed if you wish to use tuning instruments. (3) As an induction coil, using batteries, but not the 110 volts, you could probably get a thin 2 in. spark, but, as a closed-core transformer on alternating current, not over ¼ in., but very thick. (4) There are many good, reliable concerns now making wireless apparatus. Send to some of the advertisers in this magazine for their catalogs.

1733. **Pump.** H. D. K., Erie, Pa., is proposing to make a table fountain, to be operated by a small pump and electric motor, and asks several questions as to the practicability of the scheme. Ans.—Of course a double-acting pump should be used, but the one to which you referred, described in the March, 1909, magazine, is rather an extravagant construction, except for a person who has access to a plumber's scrap heap. It would be well for you to get a catalog of a manufacturer of small hand pumps, and the address of such can easily be obtained by consulting such periodicals as you may find in a plumber's or steam fitter's office, and observe some of the simple cuts displayed in the lists. If you have tools, you can easily construct patterns and make a pump of your own design. You might be able to purchase a second-hand one at a garage, perhaps of the sort used for getting up pressure in the tank of a Stanley steam carriage. Your proposition to drive such a pump by use of a fan motor is not practicable, for such a motor running without its fan gets very hot. You would need a small "power" motor.

1734. **Solenoid.** S. O. H., Mosgrove, Pa., writes that he is constructing an apparatus which makes use of a large number of small solenoids in a very restricted space, and would like to have some information on the subject. What will be the dimensions of a solenoid which will give a "pull" equal to the lifting of a weight of 5 or 6 oz., not including the weight of the core? What size wire should be used, and how much? Will want to use about 10 or 12 volts furnished by dry cells. The solenoids will have to be as small as it is possible to make them, and at the same time give the above requirements. Ans.—Such a design would involve considerable calculation and perhaps experiment. We would advise you to procure a copy of Underwood's book on the "Electromagnet," which we would be pleased to furnish at $1.00. Mr. Underwood has made a special study of such topics and has been the chief designer for a large manufacturing company.

1735. **Armature Construction.** W. H. B., Chicago, Ill., asks: For a book in regard to armature and field calculations. I want a book that will tell me just how to calculate the size and amount of wire necessary for armature and fields of motors and dynamos, also how to calculate how much current a dynamo is generating. Ans.—This question involves the whole field of dynamo design, and no one book or short course of reading will give the information desired. Underwood's book on the "Electromagnet," Hobart's "Armature Construction," and "The Electric Motor," are first-class, but perhaps beyond the scope of the enquirer. I would recommend that he take a course in direct-current dynamo design in one of the Correspondence Schools.

1736. **Wireless.** H. A. W., Chicago, Ill., asks: Would consider it a great favor if you would give me the facts of possibilities of danger in a receiving station in wireless telegraphy. I expect to use your statement as a standback in obtaining permission in erecting a receiving station. Ans.—We believe there would be no danger in receiving stations in wireless telegraphy except from lightning, and in this, as in other similar stations, it is well to show prudence, and we would advise grounding aerials outdoors during a thunder storm.

1737. **Spark Coil.** S. R. W., Stoneham, Mass., asks: I have purchased a home-made coil, the design of which I do not like, especially as regards the core which is 6 in. long and 1¾ in. in diameter. Independent interrupter is used. Do not know the dimensions of primary, but it is insulated from secondary by ordinary mailing tube. The secondary contains 3 lbs. of No. 32 and ½ lb. of No. 36 B.&S. wire, and is wound in seven sections. Distance between heads 5½ in. At present gives ⅝ in. spark between needle points. Will you kindly advise me as to the best way to rebuild this coil so as to give greatest efficiency for wireless purposes? Ans.—Your coil is not appropriately designed for good work—the coil is too large in diameter for its length. You will get 3 to 4 in. spark with the amount of secondary you use. An excellent series of articles on a 6 in. coil were written by Mr. Thomas Stanleigh in magazine numbers for February, March, April and May, 1911, and an article particularly on the insulation of coils in the May number, 1910.

1738. **Wireless Diagram.** F. M. L., Portland, Ore., asks: (1) Please tell me where I can find a diagram for the following set: aerial, six aluminum wires No. 14 B.&S., 2 ft. apart, 60 ft. high, 75 ft. long; three slide tuning coil, No. 24 B.&S. enameled wire on core 3 in. in diameter, 9 in. long; silicon detector; variable and fixed condensers. (2) The wave length of the set. (3) How can I improve the set? Ans.—(1) See Fig. 48, page 97, of the "Manual of Wireless Telegraphy for Use of Naval Electricians," 1909 edition. This will give you a choice of several diagrams employing the instruments mentioned. (2) Impossible to state, owing to variation caused by local conditions. (3) By using an inductively coupled tuner.

1739. **Slide Wire Bridge.** R. F. A., Carmine, Tex., asks: I wish to make a resistance set for a slide wire bridge with steps as follows, viz., 5, 10, 25, 50, 100, 300, 500, 1,000 and 5,000 ohms, and wish to know what size German silver wire to use. (2) What is the largest number of telephones that can be used on one line (bridging); phones are equipped with 5 bar generators and 2,500 ohm ringers? Ans.—The resistance of German silver wire varies greatly with the percentage of nickel contained in it. Since this is very uncertain in ordinary German silver wire, you cannot make coils which will be close enough to the values you desire to make reliable standards. You had better purchase the coils.

1740. **Storage Battery.** H. McC., Omaha, Neb., asks: (1) How to remove sulphate from the plates. (2) Why is it allowable to speak of positive and negative terminals of an induction coil, when the current is confessedly alternating? Ans.—(1) Several means are common. One consists in charging the cells for a considerable time, but with a small current, in the reversed direction. This is also an effective remedy for restoring the capacity of old negative plates. Another method is to charge the cells in the usual direction, using a caustic soda solution in place of the acid. After restoring the proper color of the plates, the soda must be washed and soaked out, and the ordinary solution replaced. Still another method that is about as cheap, and eminently successful, is to throw the sulphated plates away, or sell them to a junk man, and buy new ones. (2) It is true that the currents are alternating, but the impulse following the break of the primary circuit is so much greater than that following the make, that the above expressions are understood.

1741. **Switchboard.** A. H. M. G., Toronto, Can., has two direct current generators that operate in parallel. One of these is of twice the ampere capacity of the other. It is proposed to install a third machine, of twice the capacity of the larger now in use. From limitations of space, the switchboard for the new one will be 10 ft. distant from the others. What will be the best way to regulate the voltage when "cutting in" or "cutting out"? Ans.—You did not state whether the machines are compound or plain shunt. If the latter is the case, you will of course need no equalizer. If compound, the new panel may well have one double-pole switch for the positive side of line and equalizer, and a single-pole switch for the negative line, ammeter being included in this side. Only one voltmeter for the three machines should be used, and this mounted on a bracket in such a manner as to be visible from the three panels. Bus bars will, of course, extend between the two boards. A dummy hand wheel can be placed on the present board and connected by means of a sprocket chain to the rheostat on the new panel. All the operations, except closing and opening the main switches, can, therefore, be controlled from the present position. If this suggestion is not feasible, we will be pleased to explain some other means, though not so simple or cheap.

**1742. Train Lighting.** E. W. M., New Springfield, N.Y., asks how trains are electrically lighted. Ans.—This is one of the most troublesome problems in electrical engineering. The three methods you ask about are all used, but the expense is considerable, and it is difficult to see how the railroad companies can afford them for all trains. Each has its advantages and disadvantages. A small generator in the baggage car or on the locomotive may be used, but when shifting locomotives the lights go out. Some trains use storage batteries alone, but without special attention the voltage does not remain sufficiently constant, and for long runs, the batteries are heavy and expensive. The scheme of letting each car have a small dynamo driven from the axle, in connection with a storage battery is largely used, and with increasing success. Only during stops at stations are the batteries called upon, therefore they need not be of large size. Automatic devices connect or disconnect the cells for proper charging.

**1743. Loss of Voltage.** G. C., Upper Sandusky, O., asks several questions about the flow of current in a conductor, and as to whether all the current comes back to a generator. Ans. —Your difficulties come from a serious confusion of the meaning of volts and amperes. It is certain that all the current a machine generates comes back to it. This is easily proved by putting two ammeters in circuit,—one in each lead from generator. If the instruments are right, they will both indicate the same. A single ammeter may be used, first in one main, then in the other, but you might not wish to interrupt the service during the change, or there might be some doubt if the actual load was the same at the two different times. Your trouble comes from considering how the whole 240 volts are used. It is a simple idea that the lamps may get 220, for they purposely have a high resistance, while the line must require some volts, for there is no perfect conductor. The 20 volts constitute the "line drop" in pressure, just as there is a drop in pressure in a water system when a large draught is made. All the water that is pumped into the pipes, after they are once filled, has to come out. That constitutes the current (of water). In the electrical case there is an analogy that matches the requirement of first filling the pipes, for a charging current is initially supplied to the line,—of no consequence for low voltages, but of measurable and serious effect in high voltage systems. Your question is merely how the expenditure of 240 volts is distributed in the system. The dynamo may really be generating 260, for there is an appreciable waste in the armature due to its resistance. There is a loss of about 1 volt at each set of brushes. There may be equal or greater losses in the connections and instruments at the switchboard.

**1744. Choking Coil.** W. J. K., Lombard, Ill., asks for directions for making such a device for controlling the lamp for a moving-picture apparatus, to pass a current of from 30 to 50 amperes, when taken from 60 or 133 cycle circuits at 110 volts pressure. Also would this coil be more appropriate than a transformer? Ans.—The two-coil transformer would not answer, for at the starting of the arc, a practical short circuit would exist on the secondary, and the primary always imitates what the secondary is doing. You would have to have a resistance or choking coil in this secondary circuit, so the best thing is to comprise the double function of voltage reduction and control in one device—*i.e.*, the choke coil. Sheet iron 28 x 84 in. may be obtained and cut into 7 x 12 in. sheets, a sufficient number being used to give a stack 2¾ in. high. Remove a piece 2½ x 9¾ in. from each, as cut from the narrow end, so as to leave square cornered U-shaped pieces, 2¼ in. wide in every part, with an opening 2½ in. wide. Shears will take two of the cuts, while the third may be managed with a sharp cold chisel against the edge of a vise. From half the sheets clip off one of the ends 2¼ in. shorter than the other. The purpose of this will appear later. Paint the sheets with thin asphaltum, and clamp them together, the short ones alternating with the long, but with the latter all on the same prong, and bind them with a complete layer of strong twine, excepting on the end where the sheets are incomplete. Wind tough Manila paper on the other prong, to a thickness of 1/16 in. Wind, either directly in place over this insulation, or else on a suitable form, nine layers of No. 10 d.c.c. wire, five wires in parallel, eleven turns (55 wires) per layer. This sub-division of the conductor will be easier to wind than a single conductor of equivalent section, and will greatly reduce the heat resulting from eddy currents. Now slip the pieces of sheet iron that were cut from the center in between the openings in the exposed prong until they come within ¼ in. or ½ in. of the other end of the U. This provision gives the adjustment you need for meeting the varying conditions, for this separation, or air gap, in the magnetic circuit will prevent the iron from saturating with too small currents. If the hum resulting from the vibration of the sheets is troublesome, you can fill in the empty spaces in the adjusting strips with cardboard, and clamp the mass together. Do not use any volts, however, through the sheets, nor indeed outside the sheets in the vicinity of the air gap.

# CORRESPONDENCE

*Dear Sirs:* In the February number on page 139, a question was asked by R. B., Oak Park, Ill., for the dimensions of a 2 k.w. transformer, and, having built one of the said capacity, I wish therefore to state its dimensions which I hope I shall see in print: length of iron, 17½ in.; width of iron, 8¾ in.; thickness and width of core, 2¼ in.; primary wire, No. 8 d.c.c.; length of primary coil winding, 10¼ in.; primary wire d.c.c. 13½ lbs., three layers; 18½ amperes taken at full load; No. 28 secondary wire d.c.c., 21 lbs.; 30 pies ¼ in. thick, 920 turns per pie; size of square opening in pie 2¾ in.; about 15 amperes lowest voltage; range, 300 miles, doubled by night or over water. Yours very truly,

WM. STENGLE.

P.S.—Finally, I wish to state that any person without much knowledge of making transformers would better not attempt it, as it will most surely result in failure. W.S.

Editor of *Electrician and Mechanic.*

*Sir:* In reference to your editorial in regard to the wishes of subscribers as to the subjects they would like to have you publish in your very valuable magazine for the ensuing year. I, for one, would like to see some of the subjects you mention in your article, such as mechanical drawing, with the mathematics to go with the different designs; telephone engineering, with the troubles met with in every-day practice, with the addition of an article on the every-day troubles of the dynamos and motors; one on storage batteries; arc rectifiers; rotary converters; also an article on electrical calculations of wiring for lighting and motors for single-phase, two-phase and three-phase distribution.

As I find that a very large number of men working at the electric business today do not know how to figure wire at all and those that know how to figure common wiring do not know anything about three-wire service or the figuring of two and three-phase calculations.

There does not seem to be at the present time a practical magazine on the market other than yours that seems to cover the subjects that I mentioned in a practical way for the every-day workman is installing all classes of this apparatus all the time. If some magazine would treat these subjects in a good practical way that one could understand and so that it would be of some practical use to them, I think that the magazine would find a very large increase in its sales.

I have been buying your very valuable book now for about six months at the newstands, and find it as near to my idea of a magazine for the practical every-day worker as I have found so far, and I have been a subscriber to several other technical magazines for years, and they either do not go deep enough into the subject, or it is made too much of a laboratory and not a practical treatise of the subject.

I am a practical electrician, working at the business every day and belong to the Electrical Worker's Union, and I know that there are hundreds of men working at the business that are very anxious for a good practical magazine on these subjects.

Respectfully yours,

FRED'K. A. COKER.

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Editor of *Electrician and Mechanic.*

*Sir:* In the January, 1912, issue of the *Electrician and Mechanic* I noted under the heading "Correspondence" the item by Mr. Cecil A. Wanner, regarding the present form of the *Electrician and Mechanic* as compared with the "old style," as he terms it; also his suggestions to you that the magazine should specialize in certain articles.

I heartily congratulate the management and publishing department of the *Electrician and Mechanic* on the many excellent articles that are published monthly in the magazine. The articles are written in simple semi-technical language, and a feature which I think makes them extremely useful and practical is that mathematics is employed in sufficient quantity to make them a real tool in every-day work. This is a marked contrast to the many so-called popular articles in which one is usually at a loss to know just what the author means to convey. In my experience in the mechanical field, and in my work as civil engineer I subscribe to a number of magazines and journals, each treating a special line of work, but I enjoy to peruse the pages of the *Electrician and Mechanic* for the many practical articles of a *general* interest, in which I always find some suited to my particular needs.

In answer to the inquiry of the publisher under the caption "Editorial," I beg to say, that a series of articles in mechanical drawing and simple machine design, including elementary practical mathematics, ought to prove of general interest and value to a great number of readers, also the suggested articles as further named. Personally, I always appreciate an article on some subject of applied science. Articles on marine engines, steam, gas and water turbines and oil-consuming engines will interest me particularly.

It seems to me that your correspondent ought to remember that not all of the subscribers are interested in wireless telegraphy, etc., and that the *Electrician and Mechanic* in its present form during the period of the year provides a good many articles of special interest to the varied tastes of its subscribers and fills a niche of its own in the Temple of Modern Science and Invention.

Yours very truly,

C. O. THON.

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Editor of *Electrician and Mechanic.*

*Sir:* May I, as a foreign reader of your excellent magazine, be permitted to give my opinion on the paper in general—the articles contained therein?

I am inclined to agree with your correspondent, Mr. Wanner, whose letter you published in the January number, that perhaps the style of your former issues was preferable to that now followed. Such a number of different subjects are now treated that not enough of one is given at one time. No doubt the diversity of subjects tends to increase the subscription lists, but it is at the expense of readers such as myself, who are desirous of knowing all about one subject. However, barring this one growl, I have nothing but praise for the lucidness, conciseness and general excellence of all your articles. Of all the papers I read, yours caps the lot for general interest and usefulness, and I must congratulate you heartily. Personally, I should like to see more space devoted to Wireless Telegraphy for Amateurs and to the construction of electrical apparatus for amateurs; but of course that may not be the opinion of the majority.

With regard to your editorial, a department for Telephone Engineering would be exceedingly interesting; also the articles on Mechanical Drawing. The other departments suggested have little interest for me.

Wishing you all the success your paper deserves, I am,

Yours truly,

LAURENCE D. HILL.

## TRADE NOTES

This year there will be held in Boston the largest Electric Show that America or the world has known.

The 1912 Boston Electric Show—international in scope—will occupy the entire Mechanics Building, which is one of the largest permanent show buildings in the world. The whole plan and scope of this great Show will make it the most complete and most comprehensive electrical exposition ever seen. The area occupied—105,000 sq. ft. of exhibit floor space—is twice as great as that of any previous show.

Duration—Five Saturdays and four full weeks—twice as long as any previous show.

The exhibition has already been advertised in every civilized country in the world where electric machinery is manufactured.

Every single electric light company in New England will actively lend its co-operation to the Boston Show, for the benefit that will come to its own business.

During the entire month of the Show there will be excursions continually operated from all New England points into Boston, both by train and trolley.

The Edison Electric Illuminating Company of Boston stands its sponsor, and acts as financial manager of the Show, not intending, however, to make a profit either for itself or for any individual, or group of individuals, but is undertaking this huge Exhibition to illustrate the practical adaptation of electric current for every walk in life.

An idea of the scale on which this Show has been projected can be gained from the fact that the exhibition itself has been planned on a basis of securing at least 250,000 paid admissions, in order to recompense the management for the actual expenses incurred before opening the Show.

The tremendous way in which this entire enterprise has been laid out is based on the fact that big things succeed best.

The opportunity of making an exhibition of your apparatus upon a wholesale scale at The 1912 Boston Electric Show is not just unusual—it is unprecedented.

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The Department of the Interior, Bureau of Mines, announces the following new publications. (List 7—December, 1911).

Bulletin 6.—Coals available for the manufacture of illuminating gas, by A. H. White and Perry Barker. 1911. 77 pp. 4 pls.

Bulletin 16.—The uses of peat for fuel and other purposes, by Charles A. Davis. 1911. 214 pp. 1 pl.

Bulletin 19.—Physical and chemical properties of the petroleums of the San Joaquin Valley, California, by I. C. Allen and W. A. Jacobs, with a chapter on analyses of natural gas from the southern California oil fields, by G. A. Burrell. 1911. 60 pp. 2 pls.

Reprints

Bulletin 21.—The significance of drafts in steam-boiler practice, by W. T. Ray and Henry Kreisinger. 62 pp. Reprint of United States Geological Survey Bulletin 367. Copies will not be sent to persons who received Bulletin 367.

Bulletin 26. Notes on explosive mine gases and dusts, by R. T. Chamberlin. 67 pp. Reprint of United States Geological Survey Bulletin 383. Copies will not be sent to persons who received Bulletin 383.

Bulletin 29.—The effect of oxygen in coal, by David White. 80 pp. 3 pls. Reprint of United States Geological Survey Bulletin 382. Copies will not be sent to persons who received Bulletin 382.

Bulletin 30.—Briquetting tests at the fuel-testing plant, Norfolk, Va., 1907–8, by C. L. Wright. 41 pp. 9 pls. Reprint of United States Geological Survey Bulletin 385. Copies will not be sent to persons who received Bulletin 385.

The Bureau of Mines has copies of these publications for free distribution, but can not give more than one copy of the same bulletin to one person. Requests for all papers can not be granted without satisfactory reason. In asking for publications please order them by number and title. Applications should be addressed to the Director of the Bureau of Mines, Washington, D.C.

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### New Cunarder for Boston Service

The *Laconia*, the new Cunarder, built primarily for the Boston-Liverpool trade, left Liverpool January 20th, on her maiden trip for New York, from which port she makes a cruise to the Mediterranean before entering the Boston service, on March 26.

The *Laconia* was launched July 27, 1911, and next to the *Mauretania*, she and her sister ship the *Franconia* are the two largest ships that have ever been constructed on the river Tyne. The leading dimensions of the *Laconia* are 625 ft. in length, 72 ft. breadth; her gross tonnage is about 18,100, and her displacement 25,000 tons. To add to the comfort of passengers by increasing the steadiness of the ship, Frahm's anti-rolling tanks have been installed. The *Laconia* is the first British ship and the first North Atlantic liner to be fitted with these tanks.

In internal arrangements the *Laconia* is as comfortable as anyone can desire. The cabins, as well as the public rooms, are lofty, spacious, well ventilated and heated. The general style of decoration in the ship is Georgian, known in America as "Colonial." The second-class accommodation has been carefully planned, and is in every way equal to what was provided for first-class passengers only a few years ago. The third-class passengers have also been well catered for. Throughout the ship every care has been taken in minutest details to ensure the safety and comfort of all on board, and it is confidently expected that the *Laconia* will enhance the reputation of both her owners and builders for producing ocean steamships which take their place in the very front rank of modern liners, and will prove equally as popular as the *Franconia*, which vessel during the first eight months she has been in commission has carried over 21,000 passengers, a sufficient proof of the public's favorable verdict.

These steamers will appeal to all New Englanders, since they are the largest steamers to enter Boston Harbor, and mark the first step towards re-establishing Boston as one of the great Atlantic ports.

The Globe Ear-Phone, an advertisement of which appears elsewhere in the pages of this magazine, is really the same as a telephone of commerce. A microphone transmitter and an electromagnetic receiver, connected by small flexible cords with a source of electric current. The transmitter is worn on a chatelaine hook, or a loop of any sort, on the clothing. In particularly favorable cases, it will be even satisfactory for hearing in a church or at the theatre, but this is rather an extreme test for the portable instrument and calls for a special church earphone equipment (not portable). The receiver is usually worn with a head band. Worn in this way, it is not very conspicuous, especially since the transmitter may be worn underneath any ordinary clothing, and the battery is carried in a pocket. It is a very effective, and, at the same time, a very convenient form of hearing instrument. The effectiveness is caused partly by the simple increase in the intensity of the sound, and partly by the direct application of the sound impulses. Furthermore, it is effective on account of the slight sharpening of every part of the wave without otherwise altering its form or phase.

It has been stated in Boston, very recently, that a woman in one of the nearby suburbs who has attended church for twenty years, heard her first sermon in fifteen years by using one of the church instruments, through which she heard every word. A small transmitter at the pulpit caught the words of the sermon and invisible wires carried the sound to the receivers which were in the church pews.

The above-mentioned Company are looking for agents to further the sale of this excellent working apparatus for deaf people, and full information can be obtained by addressing the Company at Boston, Mass.

## BOOK REVIEWS

"The Story of the Slide Rule" is the title of a little booklet issued by Geo. W. Richardson of Chicago, and in which is given a description of his new Direct-Reading Slide Rule. The slide rule has been in use for more than 300 years, and is a most valuable instrument to any individual who has to do with figures, regardless of whether he is a technical or a practical man. The Richardson Slide Rule has embodied in it all of the latest slide rule improvements, and combines in a single simple instrument a great deal of the information that the ordinary practical engineer would need to look up in his handbooks. Unlike most slide rules, the Richardson is quite inexpensive, costing but $2.50. The stock and runner of the rule are made from aluminum, while the scale is made of celluloid, highly polished and washable. Since there is no wood in its construction, the rule is free from any changes which wooden rules suffer caused by the condition of the atmosphere. The distinctive feature of this rule is that more than forty every-day problems may be solved on it with but a single setting for each. This is accomplished by means of keys and key-holes. All that is necessary is to place the key of the problem wanted (reference to which is found on the back of the rule) under the key-hole, and the answer to the problem is found directly upon the face of the rule without any further manipulation of the rule. The rule is sold in a durable cloth-bound case, is about 11 x 1¾ x ¼ in. in size, and a book of instructions (written in clear language) is furnished with each rule.

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We are in receipt of ten most instructive and interesting treatises upon the use and care of the various parts of self-propelled machines, such as motor cars, balloons and aeroplanes. These various works are all reprints of articles which have appeared in the *Automobile Journal*, and are written by Victor W. Page, M.E. The text is simple and non-technical while the illustrations are especially good. All of the different articles are bound in paper covers and range in price from 25 cents to 50 cents. A list of them is as follows:

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| The ABC of Motor Car Operation | $0.50 |
| Overhauling, Rebuilding and Equipment of the Motor Car | .50 |
| The ABC of Aerial Navigation | .50 |
| The ABC of Internal Combustion Engine, Maintenance and Repair | .35 |
| The ABC of Carburetor Construction, Maintenance and Repair | .35 |
| The ABC of Magneto Systems | .35 |
| The ABC of Battery Ignition Systems | .30 |
| Lighting the Motor Car by Electricity | .25 |
| Maintenance and Repair of Motor Car Tires | .25 |
| The ABC of Motor Car Chassis, Maintenance and Repair | .25 |

The publishers are "The Automobile Journal," Pawtucket, R.I.

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*The Second Boy's Book of Model Aeroplanes.* By Francis A. Collins. New York, The Century Co., 1911. Price, $1.20 net.

This interesting book is a most worthy successor to the author's earlier book, "The Boy's Book of Model Aeroplanes," and brings up to date both the science and sport of constructing and flying model aeroplanes. Drawings and photographs of over a hundred new model aeroplanes are shown while detailed instructions are given for building fifteen of the latest types of these little machines. Mr. Collins' entire treatment of the subject is simple, straight-forward and thorough, and the book will undoubtedly appeal to everyone who is interested in experimental aeronautics.

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*Hand-Forging and Wrought-Iron Ornamental Work.* By Thos. F. Googerty. Chicago, Popular Mechanics Co., 1911. Price, $1.00.

While many books have been written on the subjects of hand-forging and wrought-iron work, it is doubtful if any of them treat these subjects in a more helpful or practical manner than is done by Mr. Googerty. The illustrations used throughout the book are particularly clear and well chosen; the correct positions of holding the tools when working being clearly shown. Art-Craft Ironwork is steadily increasing in its popularity, but it has been difficult for the amateur to obtain any text-book which clearly pointed out the principles and methods which underlie all of this type of work. This difficulty, however, at last seems to have been overcome.