June 1925

The EXPERIMENT

Electricity ~ Radio ~ Chemistry

Edited by HUGO GERNSBACK

How to Make

A CHEMICAL FLASK MOTOR

See Page 537

12 *Pages of* EXPERIMENTAL RADIO

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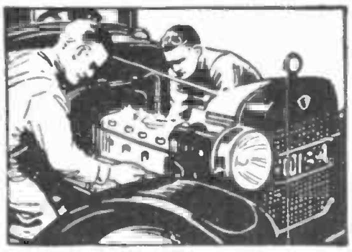

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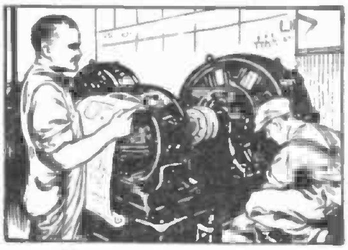

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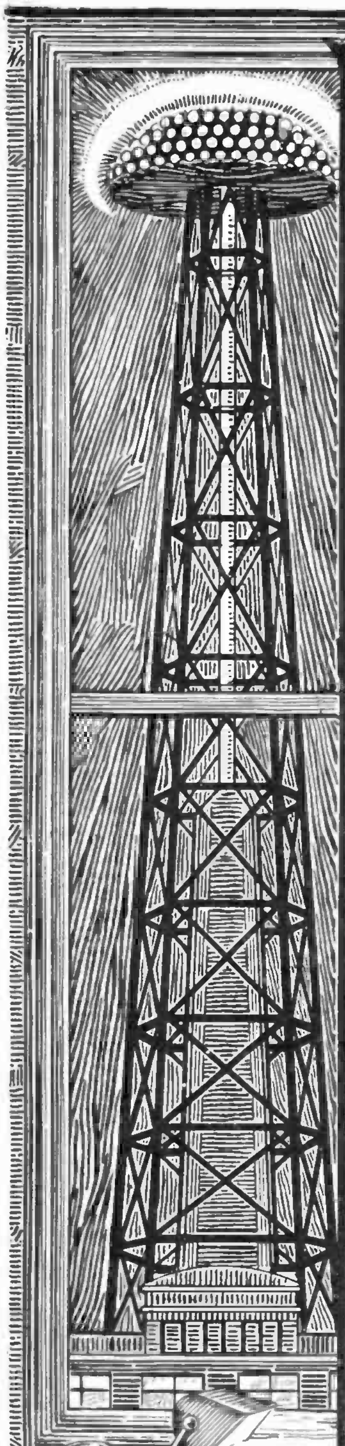

The EXPERIMENTER

Vol. 4 **No. 8**

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FOR JUNE

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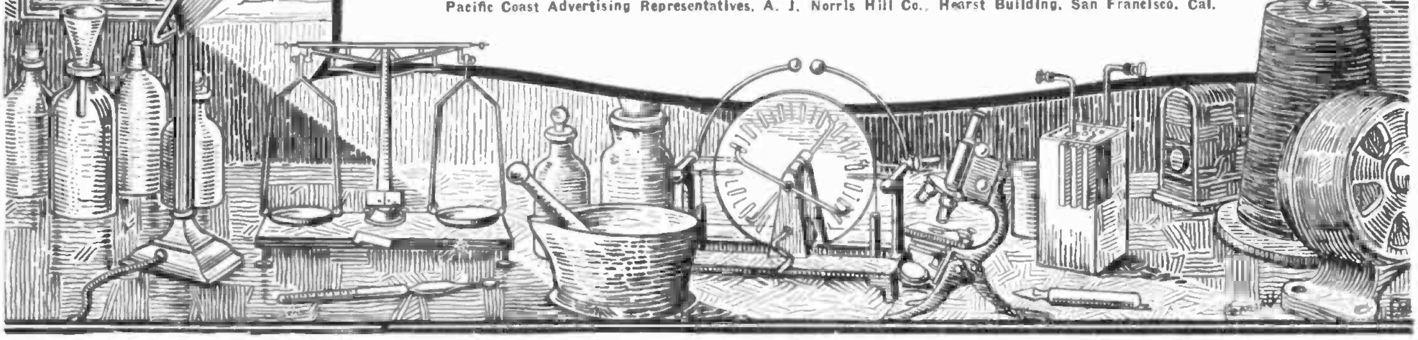

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6-25

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THIS Superadio 6 Tube Set brings in Station KFKX (Hastings, Nebraska), 1200 miles, in New York City, clearly on a loud speaker, using only the small loop which comes with the outfit.

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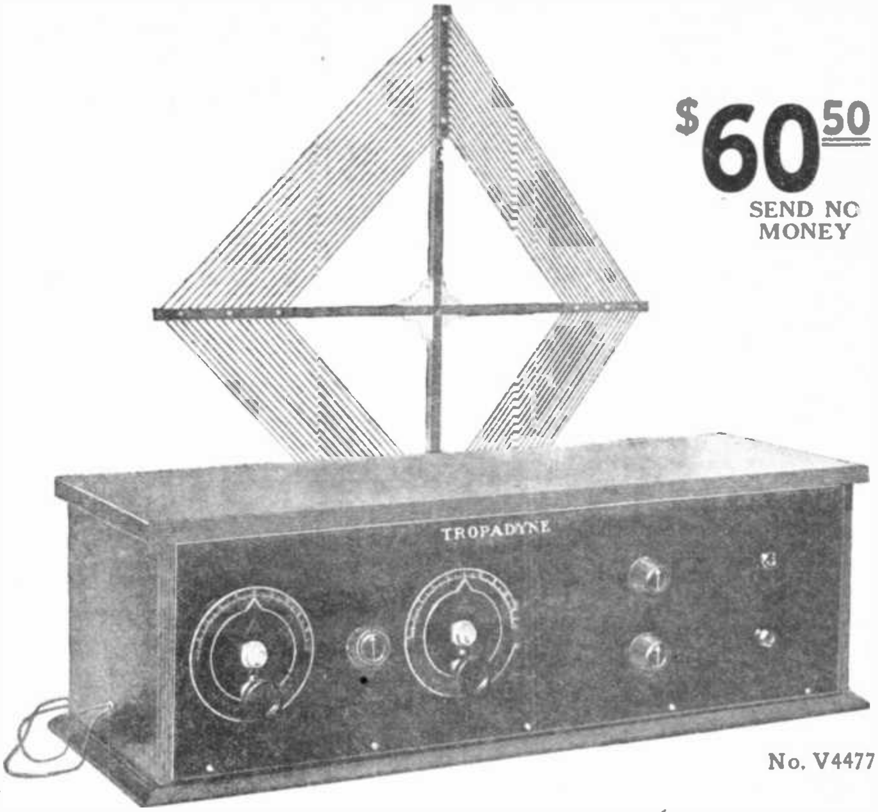

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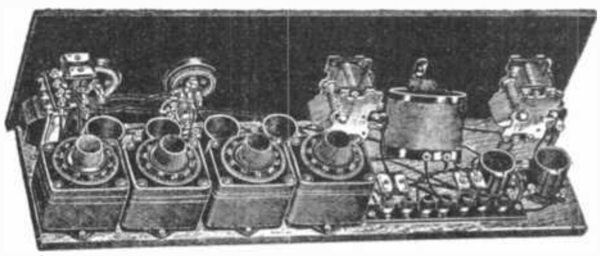
REAR VIEW OF TROPADYNE



Set uses 201A or UV-199 Tubes.

WE SHIP IN 24 HOURS

Note These Important Features:

DISTANCE, VOLUME AND TONE QUALITY equal to any 8 tube set sold anywhere at any price.

LOOP RECEPTION—Outside aerial not required with this set—the complete collapsible loop is included in outfit.

PERMANENT LOGGING OF STATIONS—Follow chart furnished; there are only two tuning controls and you will always find the same station at the same spots on the dials. Our log chart shows you at what point to find any station.

MICROMETER VERNIER DIALS giving you the full advantage of the exceptionally sharp tuning.

OUTFIT IS ABSOLUTELY COMPLETE—Drilled panel, Mahoganite Cabinet and everything else needed, except tubes and batteries.

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The Editor of Radio News

In the August 1924 issue, said this about the Tropadyne: "Here is a remarkable receiver which we warmly recommend to our readers. It has several new and unusual features. In the first place only 6 tubes are used giving as much volume as the average 8 tube Heterodyne. The selectivity of this set is unusual. Unequalities of the intermediate transformers have now been done away with by tuning each transformer. After the transformer has been tuned, it can be left this way, no further tuning being necessary.

"This system makes for maximum sharpness and maximum volume. Another outstanding point of superiority of the Tropadyne circuit is that it practically does not radiate, thereby not interfering with other nearby receiving stations. A saving of two tubes as well as an increase of selectivity is obtained with this new circuit."

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Volume 4
No. 8

The EXPERIMENTER

Electricity ~ Radio ~ Chemistry

June
1925

H. GERNSBACK, *Editor and Publisher*   T. O' CONOR SLOANE, *Ph.D., Associate Editor*

Odd Experimental Materials

By Hugo Gernsback

"An ounce of experimenting is worth a pound of theorizing"

EVERY experimenter doing experimental and research work has found when making experiments that the necessary materials are not always at hand. To be sure, the experimenter located in a large city easily makes a shopping trip and obtains the material necessary to go ahead with. But he also finds that particular parts are not always to be bought. The experimenter residing in a country district or small town is more seriously handicapped. Many articles cannot be purchased in his neighborhood at all and he must, therefore, order various parts from mail order or specialty supply houses. That means a delay and the first enthusiasm to carry out the experiment, likely as not, has waned when the material finally arrives. And we all realize the difference between working enthusiastically and working half-heartedly after the first interest has subsided.

The experimenter worth his salt, however, is generally able to cope with most situations or at least with a great majority of them. The one who has a fair laboratory or workshop, as a rule, finds no trouble in fashioning the various materials from other things on hand which, to be sure, were never intended to be used in any particular experiments.

To illustrate. The radio experimenter very often finds it necessary to wind certain tubes for inductances. Of course, if a first class job is to be had, he will wish to have special cardboard, bakelite, or fibre tubes, but these are not always available. The intrepid experimenter, however, is not daunted by their lack, and a careful search about the house usually finds the tubes forthcoming. The kitchen will yield oatmeal or other round cardboard boxes, which can always be relied upon to make an emergency tube. Even with such tubes not at hand, we can use glass bottles, of which the kitchen, cellar or garret will yield a good supply. Such bottles make particularly good "tubes" for such inductances, for want of something better. Or the rolling pin may be used by first winding heavy craft paper around it, using plenty of shellac or glue, and thus making a home-made stiff paper tube which, after treatment in a hot oven, gives a radio tube that cannot be excelled.

For condensers, two pie plates are excellent; the writer has used them frequently. Various capacities can be made with thicker or thinner dielectric material between the plates, such as thick bond paper, varnished tissue paper, a piece of thin silk, etc. By placing books or weights on top of one of the pie plates, an excellent emergency condenser is thus readily made. Old phonograph records come in handy for all sorts of insulation. The writer has seen excellent binding post strips used in radio outfits which were made by cutting out a rectangular piece from a record. This material can be cut readily after being first placed in hot water. The water, however, should not be too hot. Another good material for condensers is old celluloid film. The film can be cut to size and after removing the emulsion with hot water and drying the celluloid, such pieces can be cut to suit; then all we require is tin foil and a few pieces of wood as end-plates to finish a good fixed condenser. Phonograph records here, too, when cut to size, make good end-plates for clamping the condenser components together. The kitchen also will often yield a good supply of tin foil or heavy lead foil such as comes with tea packages, if we look for it.

The writer once required a rheostat of a certain resistance and found, to his dismay, on a Saturday evening, that he had none on hand. This meant that the work would have to stop until Monday. He found, on looking around, that he had an old microphone button, which was not being used. This was mounted rigidly on a board, while a piece of metal strip was laid over the top of the button. Through a hole in the metal strip a wood screw was screwed into the baseboard. By varying the pressure by means of the screwdriver on the wood screw, more or less pressure was put on the microphone button, and a very satisfactory rheostat was thus fashioned.

Extra resistances can be made with ordinary black lead pencils. The black lead has a high resistance and by soaking a good pencil in hot water the lead comes out easily. Most modern mechanical pencils have a supply of leads which also can be pressed into service for resistances. Colored leads cannot be used as a rule.

Also, the electrical experimenter will find many things usually thrown away that can be employed to excellent advantage. Old fuse plugs can be used to make a variety of apparatus from a microphone down to an attachment plug. Ordinary porcelain insulating tubes can be utilized in innumerable ways, in constructing heater elements, for crucibles, etc., by winding resistance wire on them. Old telephone receivers of the Bell type, as well as the watch-case type, can be used as resistances (the windings), to make microphones (the casings), and numerous other apparatus. Very satisfactory battery jars for both primary and storage battery types can be made from quart and pint bottles by cutting off the tops. This is done by taking a thick piece of string, dipping it into alcohol, gasoline, or the like, and tying it around the bottle at the point where the top is to be cut off. Stand the bottle on its base and light the cord. As soon as the flame is out, dash a few drops of cold water against the cord and in most cases the top of the bottle will come off clean, making a perfect job.

There are hundreds of different uses for old razor blades in the laboratory. With a little ingenuity scrapers and special knives, various cutting instruments, etc., can be readily fashioned. The radio experimenter will find them invaluable in marking up panels, cutting cardboard tubes with clean cuts, etc. An excellent detector can be fashioned by two razor blades mounted on a base between a block of wood, and by laying a piece of galena or silicon across the two blades.

In burnt-out electric light bulbs, the chemical experimenter finds a veritable gold mine. By cutting off the electrical part (that is, the base) by means of a diamond or glass cutter, a variety of chemical glassware can be fashioned, such as flasks, retorts, beakers, and dozens of others, too numerous to mention.

Dispensing with the Heaviside Layer

By M. Randewig

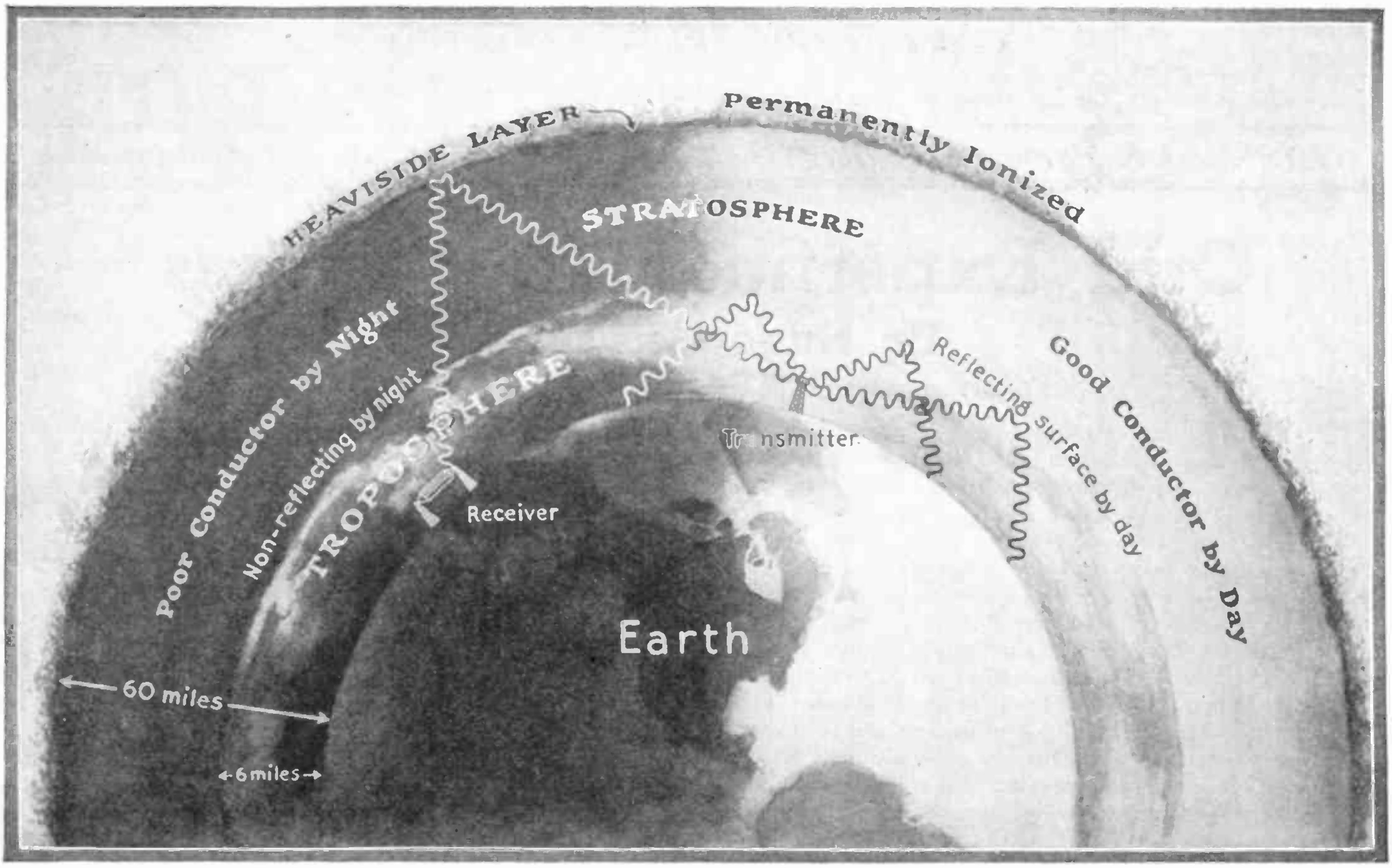


Fig. 1. A cross-section of the atmosphere according to the Heaviside theory of electromagnetic propagation. Note the transmitter in the daylight region sends out waves which are on the daylight side reflected at the stratosphere and so traverse but short distances. However, a wave crossing the day and night line before reaching the stratosphere will continue until it is reflected from the Heaviside layer and so will traverse much greater distances on the night side than on the day side.

THERE is a well known phenomenon in wireless telegraphy and telephony which is still essentially unexplained. This phenomenon is designated by the word "fading." The American expression is used internationally because of the interest that this puzzling phenomenon excited especially in America, where it was studied in the course of the development of radiocasting.

What is this remarkable phenomenon? Every radio experimenter who in daytime and at night with a comparatively long range receiver picks up distant stations, observes that with an initially loud and sharply tuned apparatus, the amplitude of the waves or loudness of the sound decreases more or less according to the time of the day and even becomes zero, and then regains its strength.

The Heaviside Theory

In explanation of the preceding enigma various attenuating—and absorption—layers were assumed to exist in the atmosphere. It is assumed that at great heights above the earth's surface—at some 60 or 75 miles altitude—an electrically conducting layer must exist. This explanation is due to an English physicist Heaviside; the layer being designated as the "Heaviside Layer."

Fig. 1 shows on the basis of this theory, the structure and the disposition of the layers above the earth's surface. The poorly conducting surface carries up to a height of about 6 miles the "Troposphere," in which most of the common meteorological phenomena occur. Above this layer spreads a second which according to recent information must be strongly ionized, that is, bearing electrically charged particles and is called the "Stratosphere." Its altitude above the surface of the earth can be assumed at about 60 miles. Above this last named layer, lies the hypothetical Heaviside layer fully ionized and electrically conductive. The origin of its conductivity is explained on the basis of ultra-violet radiations or direct electronic emissions from the sun. Ionizing rays and electrons pass through this layer and reach the layer nearer the earth, the Stratosphere, which becomes as a result more or less conductive.

Now, it is an experimentally demonstrated fact that ionized air layers behave like good conductors; they act upon electromagnetic waves when entirely ionized, like perfect reflectors, while only partially ionized layers reflect imperfectly and tend to absorb the waves. In consequence in the day time, when the partly ionized stratosphere is incompletely reflective, electric waves will be partially absorbed and refracted and only very little reflected. That is, the path of the radio waves will appear as shown in Fig. 2.

The wave motion by night is quite different; the middle layer, the stratosphere, which in daytime is ionized will in evenings and night-time be no longer under the influence of ionizing sunlight and acts exactly as an insulator, a non-conductor. Electromagnetic waves under these conditions traverse non-conductors with almost no loss of energy and radiate into space until they impinge on the Heaviside layer which is continuously permeated with ions. Here the electromagnetic waves are reflected, as light waves are, making the angle of incidence equal to the angle of reflection, as Fig. 2 shows.

From this it is evident that a wave undergoing a perfect reflection will return without weakening. It is therefore enabled, as a result of the great distance of the reflecting layer to traverse longer paths, and, as the picture shows, cover greater areas on the earth's surface. So by day we have shorter transmission distance and attenuated wave energy, hence, weaker reception, and by night longer transmission distance, strong wave energy and therefore stronger reception.

In the above considerations it will be observed that the individual layers concentrically surround the earth, and present the same characteristics in all directions.

It follows then that in twilight phenomena, which result from the migration of electrons from one layer to another, an irregular and rapid variation in the reflection must take place. This affects all phenomena depending on the wave path such as the increase and decrease of tone amplitude. In Fig. 3 this event is represented. The lines from the transmitter denote the wave path. The layers I, II, III and IV are reflecting layers which arise from the migration of electrons, and which change their position and are formed within very short time intervals. We can see that when layer III is favorably located the wave is so reflected that it falls exactly on the receiving station. As this layer in a short time assumes the position II, I and IV, the path of the waves is necessarily changed as illustrated, and the wave wanders over the surface of the earth touching it irregularly here and there. That is, the reception is subject to the nearby disturbances, and the station receives weakened signals from the transmitter, which are sometimes completely obliterated.

Another phenomenon is to be observed:

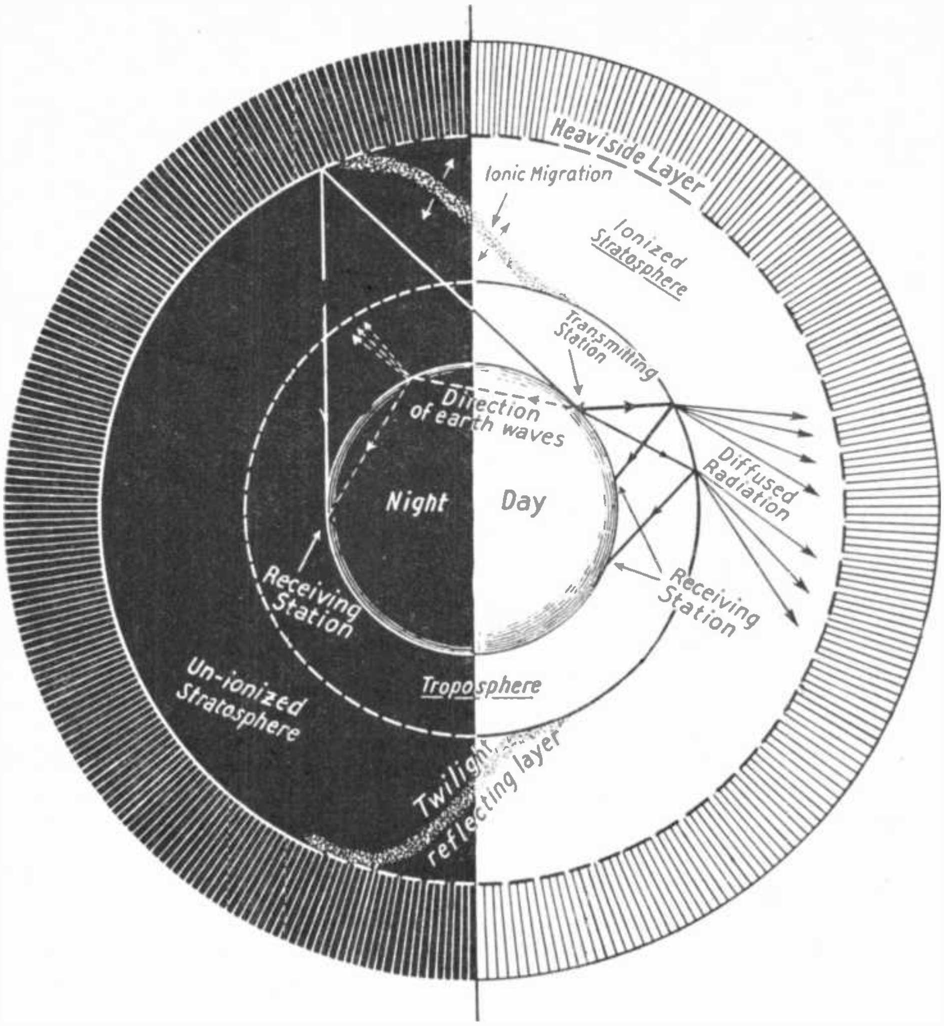


Fig. 2. Diagram illustrates various forms of propagating radio waves. Reflection from the stratosphere involves great loss of energy through diffused radiation. Similarly waves propagated through the earth lose much of their energy upon reflection through the interior surface.

the waves radiate not only cut through space but are propagated also along the surface of the earth and will be reflected on the earth's inner surface as in a hollow spherical mirror, as indicated in Fig. 2. The waves arriving at the receiving station along this path are highly attenuated as a result of the imperfect reflection from the surface of the earth, which does not present a perfect reflecting surface to the radio wave.

The theory underlying the reflection of radio waves is by some scientists connected with the electron theory. It is maintained that such reflection takes place only from surfaces of substances in which large number of free electrons are found. In free space, as a rule, no free electrons are to be found and electromagnetic waves traverse free space without reflection or absorption, and so also in the cases under discussion where reflection takes place only from strata of highly ionized atmosphere.

It is interesting to note in this connection that reflection from conducting surfaces such as sheets of metal or large networks of wire takes place precisely because such conducting surfaces have large numbers of free electrons in them. It was by virtue of this characteristic that Marconi recently succeeded with his reflecting antenna. It is also due to this effect that large steel structures or mountains containing large masses of metallic ore impede the propagation of electromagnetic waves in their direction.

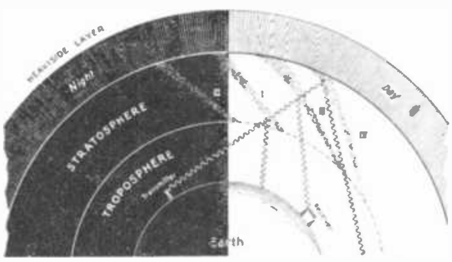


Fig. 3. The fading phenomena is effectively illustrated by the diagram which shows ionized reflecting layers in the stratosphere. These layers change position irregularly and rapidly, with the result that the reflected radio waves as received at the receiving station vary in intensity.

The Meissner Theory

Until about two years ago we were quite satisfied with the hypothetical assumptions detailed above. Until then wave-lengths of 500 to 1,000 meters were common, and their characteristics as regards propagation and distance-possibilities were explained accurately enough on the basis of the Heaviside theory. However, shortly after the war came the publication of information which till then had been kept from the public. It was necessary in the course of research establishing short waves, to observe that while an assumption of a conductive Heaviside layer explains the fluctuations of the intensities of long waves the transmission distance and transmission energy of short waves indicate characteristics which the previously accepted theory contradicted. The surprising transmission results between Europe and America showed that reflection and absorption phenomena played a much more important part than had been supposed.

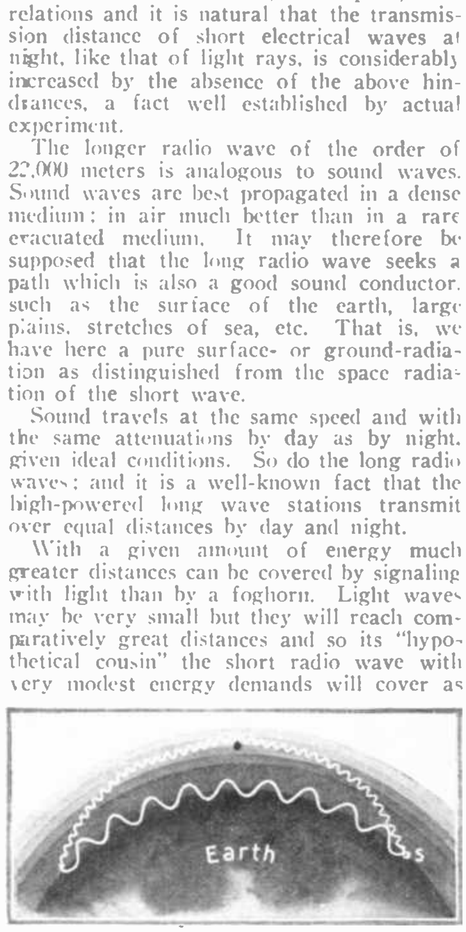
At this stage the concept was initiated whose development and exposition is due to Dr. Meissner, chief engineer of the Telefunken Company. According to this theory, a ground-wave radiation for long waves and a space radiation for short waves is assumed. The shorter the radio waves become, the more closely do they approach light radiations in their action and characteristics. Light waves undergo refraction, interference and absorption in the lower atmosphere and give rise to the familiar refraction phenomenon of the mirage (Fata Morgana). It is therefore supposed under the Meissner theory that the short radio waves, by virtue of refraction in the air, travel around the earth without the necessity of reaching the distant Heaviside layer by a roundabout path. These waves naturally chose the shorter path through the refracting lower atmosphere and so are subjected to the influences same as, or similar to, those which affect light rays.

They are influenced by the meteorological characteristics of humidity, pressure, and temperature of the atmosphere and the concomitant phenomena of rain, fog, snow, clouds, etc. All these are conditions which hinder more or less the penetration of light rays. The band of longer light waves and the short radio waves are, so to speak, close relations and it is natural that the transmission distance of short electrical waves at night, like that of light rays, is considerably increased by the absence of the above hindrances, a fact well established by actual experiment.

The longer radio wave of the order of 22,000 meters is analogous to sound waves. Sound waves are best propagated in a dense medium; in air much better than in a rare evacuated medium. It may therefore be supposed that the long radio wave seeks a path which is also a good sound conductor, such as the surface of the earth, large plains, stretches of sea, etc. That is, we have here a pure surface- or ground-radiation as distinguished from the space radiation of the short wave.

Sound travels at the same speed and with the same attenuations by day as by night, given ideal conditions. So do the long radio waves; and it is a well-known fact that the high-powered long wave stations transmit over equal distances by day and night.

With a given amount of energy much greater distances can be covered by signaling with light than by a foghorn. Light waves may be very small but they will reach comparatively great distances and so its "hypothetical cousin" the short radio wave with very modest energy demands will cover as

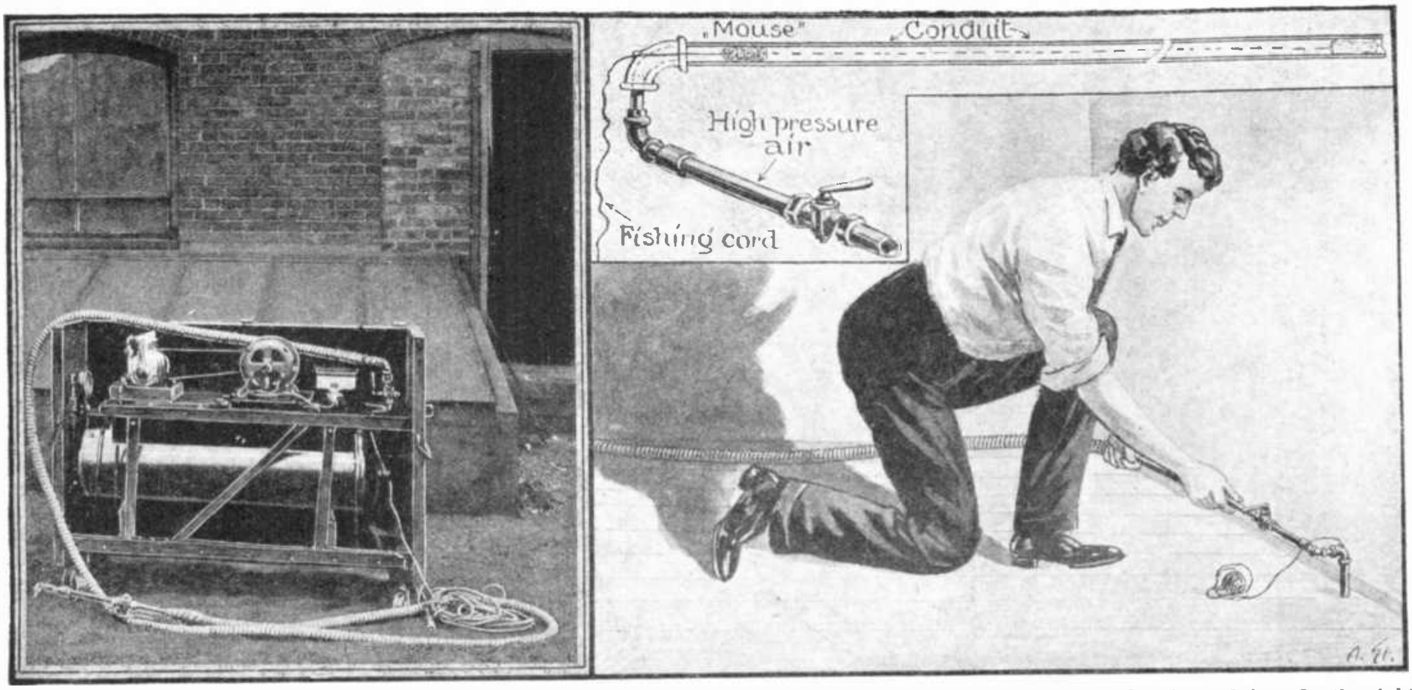


According to the Meissner theory of radio transmission the short waves undergo an influence similar to that which gives rise to mirage, that is, refraction. This refraction at various layers of the atmosphere causes these short waves to bend around the earth. The long waves are transmitted partially through the dense medium of the earth.

great a distance as the longer waves consuming enormous quantities of energy. Light can be directed by reflectors, and sound by megaphones, but the long radio wave cannot be directed because the means for such direction are lacking, namely a suitable antenna system. The short wave, however, needs only a small parabolic antenna system with which Marconi has recently succeeded in sending short waves in a single direction with only a fraction of the energy consumption required for long waves.

We can dispense with a hypothetical Heaviside layer, for from the analogies here suggested further relations and similarities can be drawn between radio waves and phenomenon of Optics and Acoustics.

Cleaner for Electric Conduits



The left hand view shows an extemporized apparatus which a proves wonderfully useful in fishing wires into electric conduits. On the right are shown details. A wad of cotton waste or other material is attached to a strong line. After the conduit has been blown out the "mouse," as it is called, is inserted through a hole in an elbow, which is screwed into place, and the operator blows air through it at a pressure of 75 pounds to the square inch. The wad of cotton, called the mouse, is propelled to the end drawing the string through.

AN ingenious substitute for the present method of "fishing" interior conduits by hand with a wire has been found by John T. Myers, a Buffalo wireman, who has invented a machine to do the work by compressed air.

The necessity for something different in the line of fishing interior conduits arose about the time the Installation Department started work at installing the telephone system in the new Hotel Statler at Buffalo. The old method of fishing conduits with the flat steel fish tape was considered too slow for such a big job.

The apparatus consists of one compressed air tank, capable of sustaining 300 lbs. test and with 150 lbs. working pressure, and a 1¼ H. P.—110-volt motor heavy duty, belted to a four-cylinder tire pump. The whole apparatus was mounted on four wheels and inclosed with sheet iron, with hinged top cover. A check valve was installed between the pump and air tank to maintain the tank pressure, and a gauge was installed on the tank for recording the air pressure in pounds. About 75 pounds pressure was used for blowing and fishing the conduits. A relief or safety valve was installed on the tank for "Safety First" so as to prevent any over-compression in the tank, together with the necessary hose connections for carrying the compressed air to the conduits. This hose was approximately 25 feet long.

The method of "fishing" the conduit was as follows:

First the conduits were blown out. Every conduit was blown clear and clean. Second, after the conduits were blown out, they were then "fished" with the fish line left in as a pull-in line. The line was fed through a small hole in the back of 90-degree elbow of the same size as the conduit, slightly tapered at the end, allowing the line to run through and out at the nozzle end. Any suitable waste material or "mouse" was fastened on the fish line and inserted in the conduit.

By means of a lever valve located back of the nozzle, air was released which forced the "mouse" on the fish line through the conduit. This method proved so successful that two men could "clean" and "fish" an entire floor consisting of 79 rooms in two days, saving a long, laborious job, time and money. This blower can also be used for cleaning out motors and generator armatures, field coils, etc.

What the future of this new method will be and how general its application will become is not at present known. In any case the inventor is to be congratulated for his ingenuity in helping out the house electrician.

Storage Battery Pouring Ladle

THE illustration shows a pouring ladle designed especially for use about storage batteries. These are sealed by a sealing compound, something like a crude sealing wax. This ladle is designed especially to be used for melting that compound.

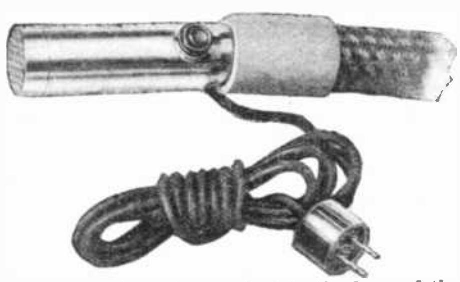
The ladle is made of aluminum, so that it is of light weight. The design brings the spout opening pretty well down to the bottom of the ladle. Cognizance has been taken in the design of the feature of balance, which makes it naturally easier to handle. Nothing is more annoying than a top-heavy ladle, or one which is too much counterpoised.

In order to protect the hand, a wooden handle is used which is hollow. The appliance is fastened together with only two screws; the design of the spout is intended to adapt it especially for this class of service, as it delivers a thin stream of melted compound to get it into close places at the top of the battery.

Stranded Monel wire leads are used and the well-known insulating beads are employed as insulators. The heating element concentrates the heat under the lip so that the compound is kept hot at the desired place; and the fact that the spout opening leads down nearly to the bottom accentuates the advantage of this location of the heating coil.

A very efficient electrically heated pouring ladle for applying the sealing compound for storage batteries. The heating coil is wound near the lip of the ladle so as to concentrate the heat there. To protect the hand a hollow wooden handle is provided.

Vacuum Cleaner Hair Dryer



This appliance is attached to the hose of the vacuum cleaner, which provides a current of air; the air is heated by a coil within the tube. This gives warm air for drying the hair after treatment.

A HAIR DRYER to be operated by the omnipresent vacuum cleaner is shown here.

It consists of a case inclosing a heating coil which is attached to the end of the pipe from the vacuum cleaner. The end of the case is perforated, so that when the current is turned into the heating coil, the vacuum cleaner is made to blow air through it, a blast of hot air is blown outwards and can be used to dry the hair.

A push-button on the case cuts off the current or lets it flow according to the temperature. Wet hair can be dried by it, if bobbed, in fifteen or twenty minutes. Longer hair requires more time. Of course, the length and thickness are the controlling factors.

The Electronic Cell

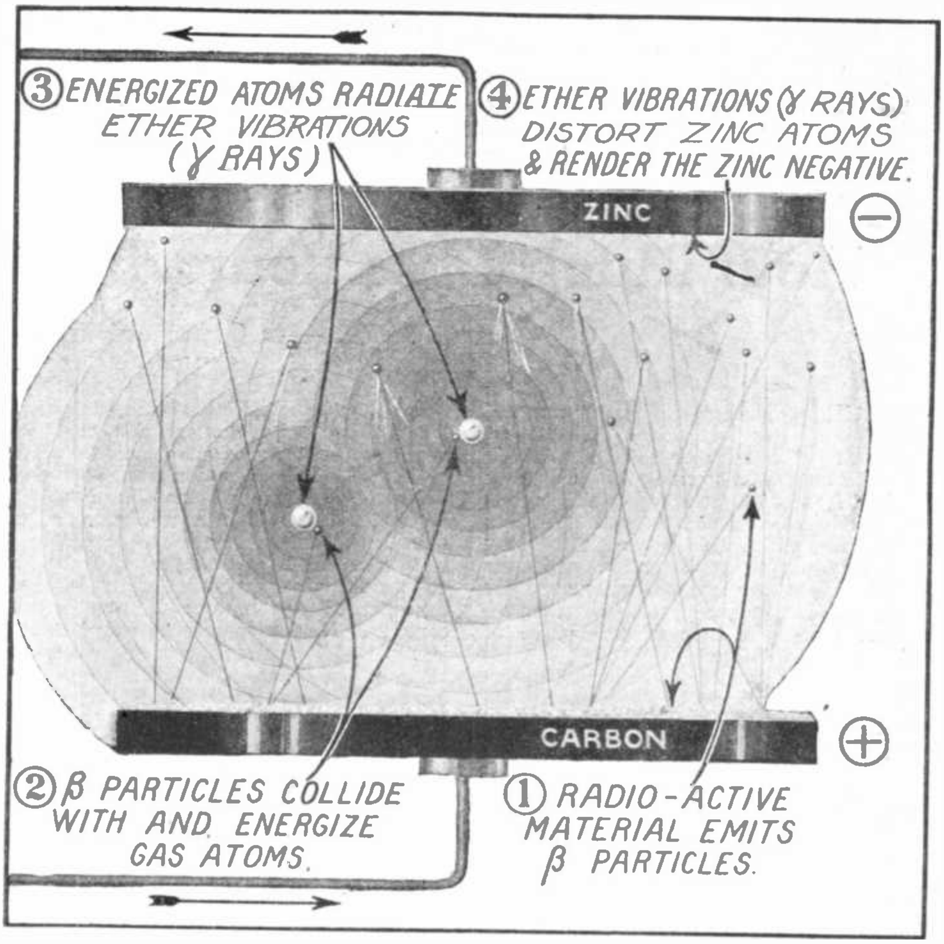
FOLLOWING a line of research which since the days of Volta has been neglected, an English scientist has devised a battery, radically different from all batteries previously in use. Mr. J. B. Kramer, to whom this discovery is due, claims to have obtained some remarkable results with these high potential, low current batteries, in which the electrolyte is replaced by a radio-active material.

A general consideration of electrification is necessary as an introduction to Mr. Kramer's investigations. According to one accepted theory, electrification of a dielectric is due to a distortion of its surface atoms. Such distortion may be brought about by the friction between two unlike substances. A familiar case of this is the electrification of a rod of glass by rubbing it with silk In this instance, the atomic systems of the atoms at the outermost layer of the glass and silk become distorted, yielding an electrical charge. This, however, is by no means the only method of producing such distortion.

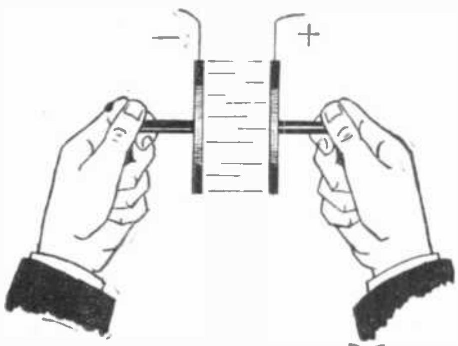
Quite early in the history of electricity, Alessandro Volta discovered that the sudden separation of two metal plates (Fig. 2) initially in contact with each other caused the two plates to be electrically charged. The potential between the two plates after separation depends on the nature of the materials of the plate. The following pairs of plates yielded the voltages indicated:

Zinc (+) Carbon (—)........ 1.089 volts
Lead (+) Carbon (—)........ 0.879 volts
Zinc (+) Copper (—)........ 0.738 volts

These values indicate that considerable electrical energy can be generated by this method. In the time of Volta and for a long while after him no satisfactory explanation was advanced for this contact electricity. Several considerations today support Mr. Kramer's distortion theory. If a zinc and carbon plate are brought in contact,



The electronic cell operating by the action of electrons emitted by radio-active substance placed on the carbon plate. Through ionization by collision with gas atoms ether vibrations are set up which charge the plates to opposite polarities. Mr. Kramer, the inventor of this cell, has constructed batteries of such cells with a potential of 25 volts.



Alessandro Volta discovered that when two discs of unlike conducting materials are brought in contact and then suddenly separated, they will be charged to opposite polarities and in some instances give potential differences of over one volt.

it is conceivable that the atoms of each plate distort the atomic systems of the other. This state is temporary and the plates lose their charge when brought into electric contact; the normal or "stable" condition is thereupon re-established. Rubbing being merely a more intimate contact than touching, the glass rod and silk represent contact electrification.

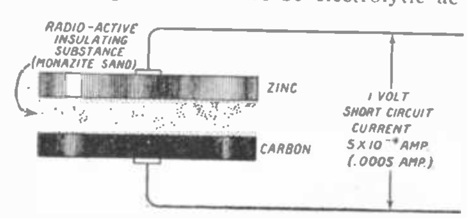
Besides rubbing and contact, electro-atomic distortion might be produced by bombarding the plate with short electromagnetic radiations. It is well known, for instance, that ultra-violet rays falling on a metal plate cause the latter to emit electrons and thereby become charged. Similar effects can be produced by X-rays and on some metals; as on sodium or potassium, ordinary visible light will produce such photo-electric effects.

Suppose, now, that two plates, say zinc and carbon, are placed in a horizontal and parallel position and that on the lower or carbon plate a small quantity of radio-active material is evenly spread. The radiations from this active substance will ionize the air and render it conductive. The arrangement will then be in effect an electric battery using ionized air for electrolyte. Such batteries have been actually constructed and can yield a current of .0005 amperes.

In such battery the electrons and alpha particles emitted by the radio-active substance collide with the atoms of the air and as a result impart some of their energy to these atoms. The atom of gas becomes distorted and in resuming its normal condition radiates electromagnetic waves. These waves are similar in nature to the radio wave, but of extremely short wave-length. Under certain conditions such excitation of an atom will cause it to emit visible light rays. In the case considered, however, these radiations are invisible. Upon impinging on the zinc plate they cause a distortion of the zinc atomic systems, with the result that the plate becomes electrically charged. This distortion or deformation of the systems of the zinc and carbon atoms is similar to the effect of an X-ray which impinging upon a solid object renders the object positively or negatively electric, according to the respectively tight or loose state in which the electrons are coupled to their respective nuclei.

In his electronic cell, Mr. Kramer found that the zinc would be the negative and the carbon the positive pole. This was opposite to the Volta (contact) effect. Two plates of the same element showed no potential difference; there would be, however, a slight potential difference between two plates of the same metal if one was at a higher temperature than the other. A slight difference in the composition of the plates would give a potential difference.

The first battery of this type had an air gap between the two plates as described. In another type in place of the air gap and the radio-active material on the carbon plate, a certain radio-active non-conducting compound was placed between the plates. For instance, having a thick layer of monazite sand or radio-active ilmenite on the carbon plate with the zinc plate directly on top of the sand (which was closely sandwiched between the top and bottom plates) steady scale deflection of a current indicating instrument resulted with the zinc as the negative and the carbon at the positive pole. There might in this case be electrolytic ac-



The electronic cell might be constructed by filling the gap between the two electrodes with a radio-active insulating substance such as monazite sand. This cell gives a current on short circuit of .0005 ampere.

tion. The potential difference in such a couple was approximately one volt and the current .0005 amperes. A small electric battery of this type yielding a potential of 25 volts has actually been constructed, and the inventor, Mr. Kramer, intends to build batteries of 100 volts.

EXPERIMENTAL RADIO

CONDUCTED BY LEON L. ADELMAN

How Much Does Your Amplifier Amplify?

By William Grunstein, E. E.

THE genuine radio experimenter, I mean, the inquisitive, experimental sort, will never be satisfied with information concerning his apparatus obtained from manufacturers' catalogues and sundry advices extended through the pages of radio magazines. He will want to get first hand information, to determine wherever possible, the nature, the characteristics, and quality of his equipment. Let the ether enthusiast once take note of this phase of radio, and his interest in distance records and freak hook-ups will dwindle to indifference before the fascinating phenomena revealed by the inner operation of divers radio instruments.

Take for instance your vacuum tubes. You have, no doubt, a collection of various sorts, of which, you were told, one works better than the other; this to be used for detection, that for amplification; that other needs a "C" battery, while still another works best with zero grid voltage. Of course, if you are a mere dilettante you will be satisfied with this information, but if you are a zealous devotee of radio you will have wondered what peculiar characteristics adapt these tubes to their particular uses. With these questions in mind the radio fan endowed with any scientific curiosity will naturally turn to experiment.

For example, consider the question of amplification: which of your tubes is the best amplifier?, at what filament current will this tube give best results?, what exactly are the amplifying capacities of your tubes? At first glance these questions may seem difficult and you will be inclined to dismiss them for reasons of insufficient knowledge or apparatus to perform the necessary experiments. Yet, note how readily the problem is solved even at a cursory analysis!

Suppose the filament current is on, and the grid and plate voltages are set to some definite values. Electrons are emitted by the filament and are attracted to the plate under the influence of the positive potential of the latter. The motion of the electrons is increased until so many are moving through the space between the plate and the filament that the negative charge due to these electrons neutralizes the positive charge due to the plate and equilibrium is established, that is, the flow of electrons becomes constant. Now suppose a positive potential is imparted to the grid, reducing partly the effect of the electronic (space) charge. An increase in the flow of electrons results and in consequence the plate current, which is due to this flow, is increased. But this increase in the plate current is very much greater than that in the grid current. If we refer to Fig. 1, this action will be somewhat clarified by the hydraulic analogy illustrated there.

It will be noted that before any water can flow from F to P the valve at F must be opened by the action of pump A. Then if the pump B is put in operation a flow in the circuit F, P, B, will result. This corresponds to the plate circuit in the electrical diagram. A part of this flow is deflected to pass through the circuit L, C, F, in which the valve L is actuated by some influence external to the system. If excessive water accumulates in the vessel C, the surplus leaks off through the pipe R. If the valve L is opened wide the piston in C will be raised opening the passage between F, and P. Observe that a very small variation in the valve L will result in a large motion of the valve at G. During these operations the motion of the pump B has been constant but the flow in the circuit F, P, B, has varied in accordance with variations in the valve L. In terms of electrical phenomena: the plate current has varied in accordance with variations in the impulses induced in coil L, while the B battery was maintained at a constant potential. Further, the variations in plate current (circuit F, P, B) were much greater than those in the grid current (circuit F, L, G.). Such, then, is the amplifying action of a vacuum tube.

Now the increase in plate current is equivalent to an increase in plate voltage, and so, if we place in the plate circuit a counter voltage just equal to this hypothetical increase in the plate voltage we can bring the plate current back to normal.

In Fig. 2, the buzzer or other source of audio-frequency current creates an alternating potential at the terminals of the resistances a and b. It will be noticed that the resistance (a) is in the grid circuit while (b) is in the plate circuit. Suppose that at some instant the polarities are as indicated. The grid is now made slightly positive, causing an increase in the plate current. The plate current flows from plate to filament and it will be noticed is opposed in its flow by the potential across the resistance b. If while listening through the phones we adjust the resistance b, a point will be found at which the buzz in the phones ceases. Obviously in this condition any effect produced in the plate circuit by the alternations in the grid circuit are annulled by the counter potential across the resistance (b). Now a very simple mathematical analysis will show that when this condition is established the ratio of variations in the plate to that in the grid, that is the coefficient of amplification, or simply the number of times the tube amplifies, is given by dividing the resistance (b) by (a). In other words the tube amplifies b/a times.

If standard resistances are not available the resistances can be measured by any one of the common methods after the test is performed. A non-inductive resistance is preferable.

This hook-up can be used for other tests which can be devised by the experimenter.

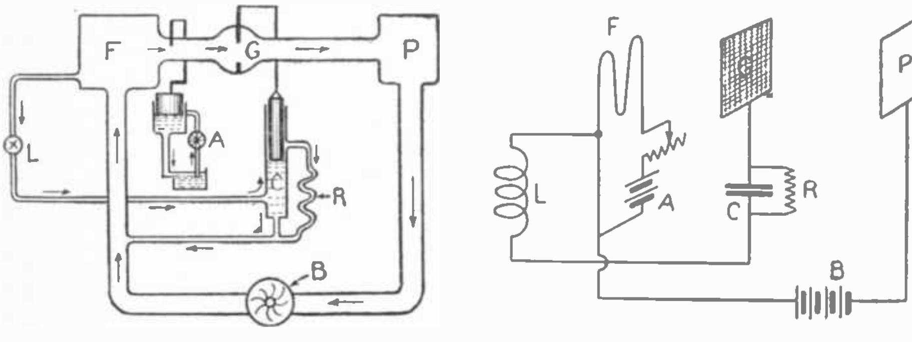


Fig. 1. The illustration shows a hydraulic system analogous in construction and operation to the electrical vacuum tube circuit. The flow of electrons in the electrical circuit is likened to the flow of water in the hydraulic circuit, and hydraulically actuated valves in the latter system correspond to the action of the grid and filament of the vacuum tube.

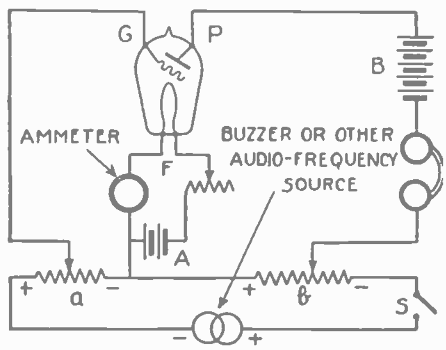
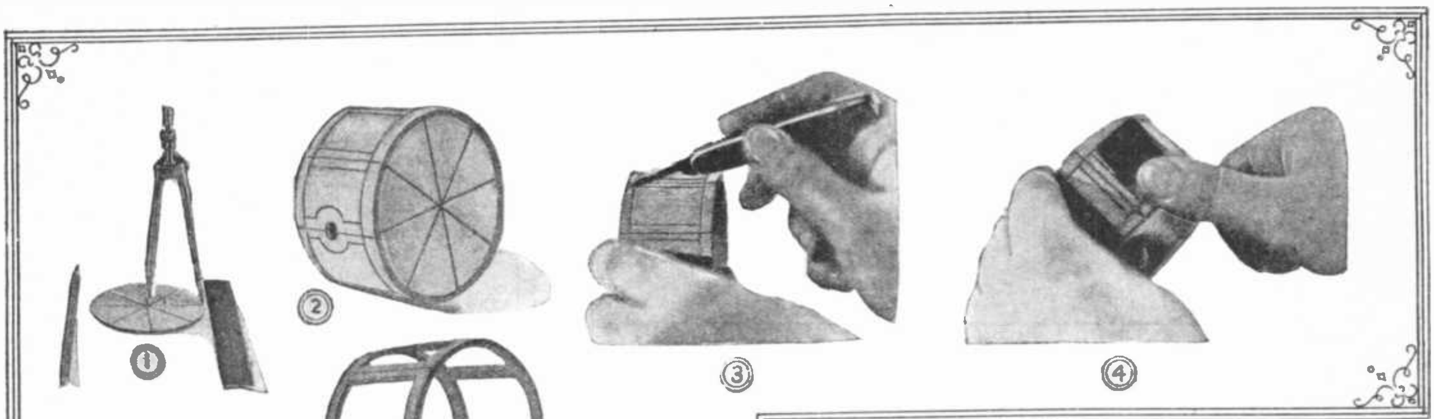
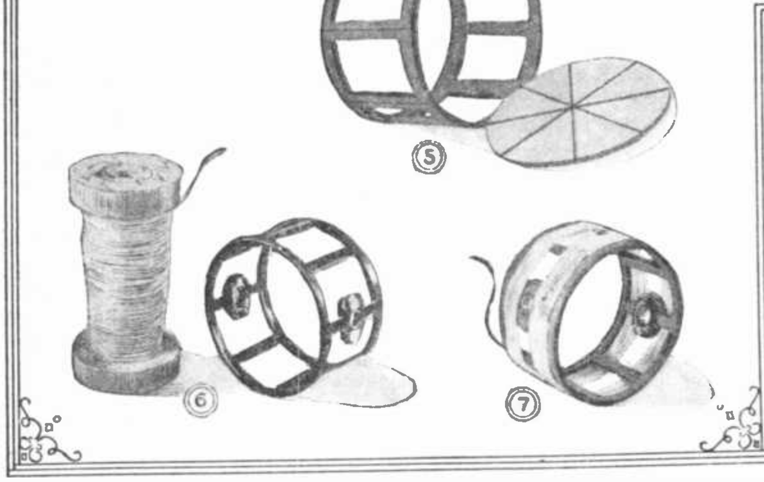


Fig. 2. The diagram represents the electrical circuit used for the determination of the coefficient of amplification. The ratio of the resistances b and a after having been adjusted to give minimum sound in the receivers, evaluates the amplifying qualities of the tube.

Experimental Low-Loss Coils

By Herbert E. Hayden

The construction of a low-loss coil is illustrated here. The form on which it is wound is made of cardboard. Fig. 1 shows that after a circle of approximately 3½ inches in diameter has been described, it is divided with pencil into eight equal parts so that it will appear as shown in Fig. 2. Note the hole in the form shown in Fig. 2. This is for the shaft and extends through the opposite side. After the form has been marked out as shown, we see by Fig. 3 a method of cutting out the cardboard squares. It is imperative that a sharp knife be used. When stripping the unnecessary insulation from the form, make a slicing cut and then, as shown in Fig. 4, peel the cardboard off layer by layer. By attempting to do this operation with a dull knife the probability is that you will crush the entire form. When the peeling operation has been completed, the form will be similar to Fig. 5. Obviously, it will have many jagged edges, so the coil is treated with one or two coats of orange shellac which will soon harden the cardboard form. With this hard surface it is comparatively simple to rid the form of the jagged edges with a small file. Fig. 6 gives another view of the coil after it has been shellacked and dried thoroughly, and shows a roll of No. 22 D.C.C. wire which is to be used for winding on this form. Fig. 7 shows the completed coil when properly constructed.

IN the making of the ever-popular low loss coil, many experimenters overlook completely the element of mechanical strength which is necessary in order to keep various factors constant.

Of the many materials lending themselves to the purpose by way of support, properly prepared cardboard tubing is not only very satisfactory from a standpoint of results, but also from that of price, which in many cases is a consideration.

The purpose of this article is to show how these low loss forms can be easily made at home and the results achieved by removing 80 per cent. of the cardboard tubing from the coil forms.

In Fig. 1 it will be seen that a circle has been described, which may be, for example, 3½ inches in diameter (just large enough to fit on the inside of a piece of cardboard tubing about 3½ inches in diameter). The circle is then divided with pencil into eight equal parts, and then the circle is cut out with a pair of heavy shears.

Next we fit this prepared circle or "marker" with the edge of the cardboard tubing as shown in Fig. 2. The points at which the edge meet the circumference are marked off and lines carried down the length of (right across) the tubing.

Parallel lines are then drawn on either side of these perpendicular lines on the cardboard. Select any one of these central lines as a center and drill a hole one-quarter inch which is to fit the shaft (assuming this coil to be a rotor coil) which will be described later. Semi-circles are drawn around this point instead of parallel lines, thus giving a little more strength at this place. Select a line diametrically opposite to it, and drill another one-quarter-inch hole for the other side of the shaft.

This brings us to Fig. 3 where the method of cutting out the cardboard "squares" is illustrated. Use a sharp knife and do not attempt to cut directly through the cardboard. If you do, you will probably crush the entire form.

Just make a slicing cut and then (Fig. 4) peel the cardboard off, layer by layer. Under no circumstances attempt to do this with a dull knife or disaster is the inevitable result.

Fig. 5 gives us a view of the coil with the marker removed and of course the cut-out form has a rather jagged appearance. This, however, is corrected by treating the coil with one or two coats of thin orange shellac which immediately hardens the form. Having this hard surface to work on, the finish is completed with a fine file.

Of course, almost any size copper wire can be used for the coils, depending on the other apparatus, such as condensers, etc., that will be used with it.

The photograph suggests No. 22 D.C.C. and this winding on the completed coil is shown in Fig. 7.

Dry-Cell Tubes with Varying Transformers

By Arthur H. Milner

SOMETIMES the uninitiated may wonder why all radio frequency and intermediate frequency transformers will not work as well with dry battery tubes, as with the storage battery tubes.

As a matter of fact, they can be made to work as well, but there must be a small condenser of approximately 10 mmf. shunted across the plate and grid of the dry battery tube to compensate for their lower internal capacity.

Since these condensers are necessarily very small and tedious to make, I am giving details for the construction of one which is very simple and efficient.

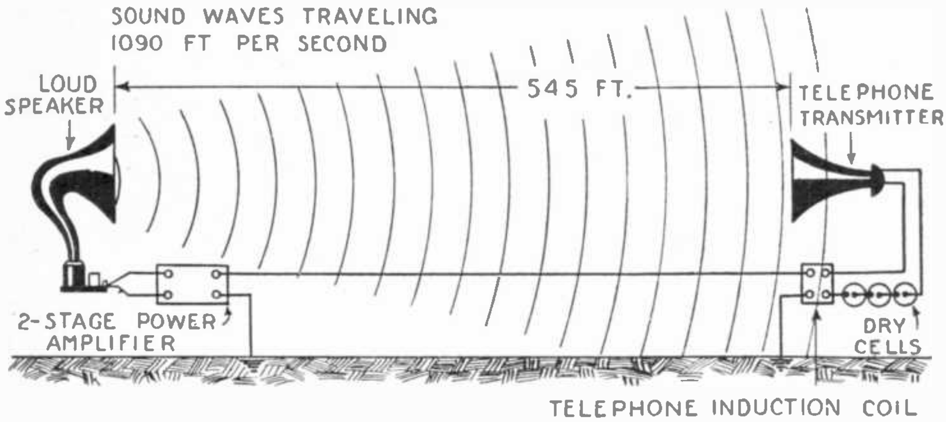
Cut one piece of 3/16 rubber or bakelite ⅝-inch square, two pieces of .005 thick brass 5/16-inch wide and 1-inch long, one piece of .005 thick mica ½-inch wide and ¾-inch long.

Next make a hacksaw cut down one edge of the hard rubber or bakelite piece ½-inch deep; this leaves ⅛-inch on the opposite edge to hold the two pieces together. Put one piece of brass on each side of the mica sheet; the overlapping area of the plates should be about 5/16-inch square; this assembly should slide snugly into the saw cut. If it does not, rub one side of your assembly with paper until it does.

In a circuit using one or more stages of self-tuned transformer-coupled radio frequency amplification, it is necessary to connect a condenser across the grid and plate of the first tube. In intermediate frequency circuits, however, it is sometimes necessary to shunt one across each tube. Always slide one plate of the condenser back and forth until the best results are obtained. Generally, best results are had when the secondaries are tuned. As a word of caution, in adjusting or putting on these condensers, always either disconnect the "B" batteries or be careful about letting the plates make a contact, or you might blow some tubes.

A "Perpetual" Radio

By Clyde J. Fitch



With a steady battery supply and other correct conditions, the above become a perpetual radio which will furnish no end of fun. A distance of at least 500 feet should separate the two instruments.

DID you ever hear a loud talker talk to itself? If not, you will probably be interested in the following experiment, which will show you how to make your loud talker talk to itself. All that is necessary to start it talking is to say something, utter some word, or make a noise or sound of any kind, and it will repeat this sound over and over again, with clock-like precision, as long as the batteries supply the energy to keep it talking. If disturbed by other sounds, it will add in all the new sounds and keep on repeating them, until there is nothing but a jumble of noises, which can have no better object of comparison than the emissions of some of the present broadcasting stations.

Almost everyone is familiar with the experiment of holding a telephone receiver near the transmitter. The receiver will howl, and it does not sound very pleasant to the party at the other end of the line. Only those who own radio sets enjoy it. Usually, some sound is necessary to start it howling, and may be explained as follows: Suppose we hold the telephone receiver up near the transmitter and say, "Hello" into the transmitter. While we are saying "Hello" into the transmitter, the receiver is also saying "Hello" into the transmitter, and both receiver and transmitter diaphragms are vibrating. These diaphragms however, do not stop vibrating the instant we finish saying "Hello," as their inertia carries them slightly beyond this point—just far enough beyond so that the sound waves continue to emanate from the receiver just as fast as they enter the transmitter, and therefore keep both diaphragms vibrating, the frequency of which is determined by the fundamental frequencies of vibration of both diaphragms and the distance they are separated.

Suppose we draw the receiver back from the transmitter, bringing them further and further apart, and see what happens. And also let us assume that the sound from the receiver will be loud enough so that it will be picked up by the transmitter at a great distance. This is easily possible with a vacuum tube amplifier in the circuit and a loud talker in place of the telephone receiver. When the distance between the transmitter and the loud talker is increased, we must take into consideration the time required for the sound waves to travel from the loud talker to the transmitter, which in dry air at 32° F. is 1,087 feet per second. The time required for the electric current to travel from the transmitter back to the loud talker is negligible, and we will not consider it here. In the picture, Fig. 1, the loud talker is shown 545 feet away from the transmitter, so that it will take about a half second for the sound waves to travel from the loud talker to the transmitter.

Now let us say "Hello" quickly into the transmitter. We must say it within half a second to have the apparatus function properly. While we are saying "Hello," the loud talker is also saying "Hello." But it will take half a second for this "Hello" from the loud talker to reach the transmitter. By this time we have finished saying "Hello" and the "Hello" from the loud talker will strike the transmitter diaphragm and is repeated again in the loud talker. Half a second later this second "Hello" from the loud talker reaches the transmitter and is repeated again in the loud talker, and so on. The loud talker will continue to say "Hello" to itself as long as we wish.

There are many sounds we could experiment with using this device. A clap of the hand will produce a series of hand claps. Four or five hand claps lasting over our half second limit will sound like a whole audience applauding a public speaker. We could save gun-powder on the Fourth of July by firing one pistol shot, which would sound like a machine gun.

This may seem all right on paper, but will it work out practically? It will do one of three things. If the sound waves from the loud talker are not loud enough to actuate the transmitter diaphragm, it will reproduce the sound weaker and weaker until it dies down to zero. If the sound from the loud talker is too loud, it will reproduce the sound louder and louder until the limit of the amplifying equipment is reached, and will continue reproducing the sound at this intensity. If this is the case, which is practical with a two-stage power amplifier, and a horn on the telephone transmitter so as to collect a large amount of sound energy, and if the original sound is slightly distorted when first coming out of the loud talker, this slightly distorted sound will be distorted a little more the second time, and a little more the third time, and so on, each time the sound getting a little worse until it is indistinguishable. The loud talker that reproduces the sound the greatest number of times is the loud talker that has the least distortion. This, therefore, is an excellent test for distortion.

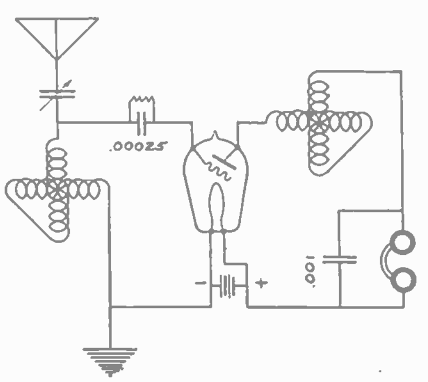
Those who wish to try this experiment must have access to a large open field, free from obstructions that are likely to cause echoes or reverberations. The apparatus can be set up as shown here, with only one wire running from the loud talker to the transmitter, as the ground can be used for the return. A telephone induction coil or modulation transformer is connected in the circuit as shown, and should be located near the transmitter, as this steps up the voltage, and there will be less energy loss in conducting the electric current to the loud talker. The loud talker should be energized by 200 to 300 volts in order to obtain sufficient volume of sound. The distance between the loud talker and the transmitter should be at least 500 feet, although greater distances may be used, provided the loud talker can talk loud enough to be heard so far away. There should be no outside noises when trying this experiment. If a dog should happen to bark near by, you might think there is a pack of wolves after you.

B-Less Set

SPEAKING of the Solodyne principle, a B batteryless set can easily be made using standard tubes. About a year ago I experimented with the standard single circuit and two circuit hook-ups. The set that I had built at the time had a plate variometer with a much larger winding than necessary and gave such good results with a very low plate voltage that I continued to reduce the B battery voltage until only 1½ volts were being used.

Trying to reduce still further, I changed the negative B battery lead from the positive A to the negative A, and again reduced it to 1½ volts. Finally I cut out the B battery, entirely connecting the detector plate battery wire to the positive A battery, and found that the set regenerated even better when the plate variometer was in tune with the grid. Using a Western Electric 216A tube, this circuit works very well on a six-volt A battery. With a DeForest DV3 it will work on two dry cells as the sole power supply (two flashlight cells, if you wish, make a very compact set).

—Contributed by Powell Ross.



This circuit works very efficiently without a "B" battery. The plate variometer must be of a large number of turns so that the set will regenerate quite easily. In building this circuit it is best to start with a comparatively small "B" battery voltage, such as 10 or 12 volts, gradually decreasing the voltage and increasing the turns on the plate coils.

"B" Battery Eliminator for Alternating Current

By Ralph Gans

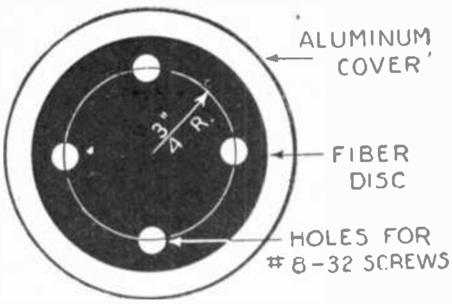


FIG. 1

The top of the rectifier jar consisting of a fibre disc attached to the aluminum cover of a fruit jar with four holes for electrodes and for adding water.

A WELL-KNOWN proverb says, "Experience is the best teacher." In experiments of the kind which do away with the "B" battery in radio sets, one should profit by the experience of another. When the author constructed his "B" battery eliminator, he failed to place a protective device in the circuit, and as a result when the current was turned on, two tubes glowed very brightly for about three seconds and have not lit since. In other words, by not using a protective device which costs only a few cents, he blew out tubes worth about eight dollars.

The writer will explain the protective device after he describes the construction of the "B" battery eliminator.

The device is for use where only alternating current is supplied from the street circuits. Whether A.C. or D.C. is available can easily be determined by looking at the name plate of the electric meter where this data is printed.

The first thing to do is to break the glass out of the inside of the cover of each Mason jar. Then cut a round hole in the metal

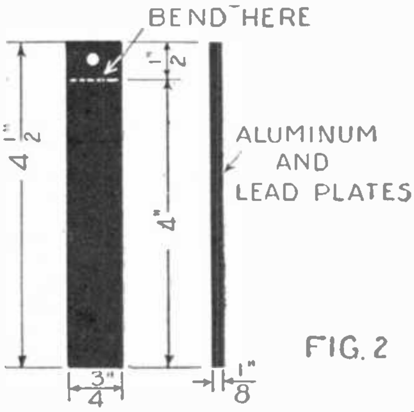


FIG. 2

Details of the aluminum and lead strips used in the electrolytic rectifier jars.

cover, so that only about 1/4 of an inch remains around the edge of the top (Fig. 1).

The fibre discs are cut to fit closely inside of the covers and rest on the top of the jars. Four holes are drilled in the discs (Fig. 1). The holes are drilled for 8/32 screws and are from 1 to 1 1/2 inches apart. Two holes are for the screws that hold the plates and the other two for adding water as needed. The plates are secured in place so that they face each other, a lead and an aluminum plate being placed in each jar.

The lead and aluminum plates, which are really electrodes, are cut to a size of about 4 1/2 by 3/4 of an inch. One-half inch at the top of each is bent over and holes drilled for the screws so that the plates can be connected easily. The measurements for the plates are clearly shown in Fig. 2.

The electrolyte is a solution of borax in water. It is best to boil the water so that a greater quantity of borax will dissolve, and on cooling some will be left in the bottom of the jars. Dissolve the borax in the water in a large container and after it is cold pour it in the individual jars to within about one inch of the top. Put the plates in the solution and connect them up as in Fig. 3.

It is next necessary to form the plates. Turn on the current and the hundred watt lamp will light brightly, gradually dimming and finally going out entirely. This will take from one to five minutes according to the quality of aluminum used. The hundred watt lamp is then taken out of the circuit and the connections are made as in Fig. 4 for use with the receiving set.

The choke coil in Fig. 4 should be either the secondary of a Ford spark coil or the

> The following parts are necessary to construct this inexpensive battery eliminator:
>
> 4 Pint Mason jars with aluminum covers.
> 3 Two mfd. condensers.
> 1 Choke coil (spark coil or transformer).
> 1 Variable grid leak 0-5 megohms with mounting.
> 4 Fibre discs to fit inside cover of Mason jars.
> 4 Aluminum plates; as specified in article.
> 4 Lead plates; as specified in article.
> 5 Binding posts.
> Quantity of wire.
> Electric plug.
> 1/2 Lb. borax.
> Distilled water.

primaries (110-volt windings) of two bell ringing transformers in series. If these are not available, the secondary of an audio frequency transformer will answer. There may be a slight hum when tuning in for a station. After a station is tuned in, the hum will not be noticeable. It is advisable to experiment with different choke coils until one is found that will entirely or nearly eliminate the hum, although in some cases it may work better without a choke coil.

The loss of potential through rectifying and filtering is about 10 volts, giving an output of 90 to 100 volts. This voltage is too high for an ordinary soft detector tube, so it is necessary to cut it down by means of the variable grid leak. This may cause a hum, which can be eliminated by connecting a 2 mfd. condenser from the negative of the eliminator to the side of the grid lead away from the positive of the eliminator. This is clearly shown in Fig. 4. If the hum is not eliminated, use a hard tube such as a 201A for detector with the full 100 volts on the plate.

The protective device is made by hooking

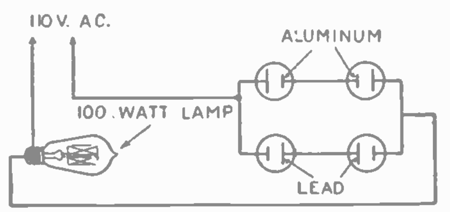


FIG. 3

Connection used for forming the film on the aluminum plates of the rectifier. The rectifier should be connected in the circuit until the lamp goes out indicating that the film has formed.

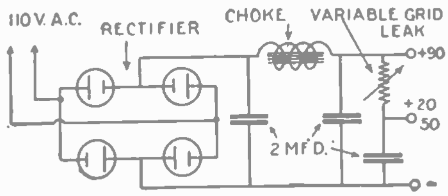


FIG 4

The complete circuit of the "B" eliminator showing the four-jar rectifier, filter condensers, and choke coil. For the detector voltage a variable grid leak is connected in series as shown.

a 50-watt lamp between the negative of the "B" battery eliminator and whatever "A" battery terminal is usually connected to the negative "B" terminal. This resistance (lamp) must be shunted by a fairly large fixed condenser 0.5 or 1 mfd. in order to provide a by-pass for the radio frequency currents (Fig. 5). If this by-pass is omitted, the volume will be reduced and a persistent howl may be the result.

In normal operation the lamp remains unlit, but the moment the plate battery or eliminator is across the "A" battery in any manner the lamp will light. This serves two purposes. First, as a sure protection against tube blowouts and second, as a signal that the plate battery or eliminator is shorted across the "A" battery.

If when the "B" battery eliminator is connected to the set and current tuned on, the lamp lights, remove the ground connection from the set. If the light goes out, it shows that the filament is grounded. There is a choice of two things to do: either to leave the ground disconnected or to break the connection where the filament is grounded. It is advisable in cases where the set is a factory-made set to disconnect the ground wire because then there is less chance of damaging the other wiring. In the case of a home-made set, it is an easy task to re-

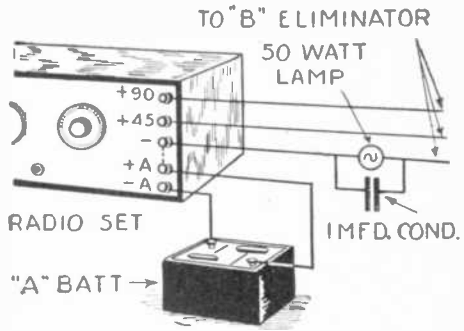


FIG. 5

In connecting the "B" eliminator to the set it is important to use a protective device which in this case consists of a 50-watt lamp shunted by a 1 mfd. bypass condenser. In case of a short circuit the lamp will limit the current to a safe value and protect the tubes.

move the connection between the filament and ground. Where the panel is shielded, the best thing to do is leave the ground disconnected. As the A.C. line is grounded, this connection serves also as a radio ground.

The completed eliminator can be mounted in a cabinet with the connections brought out to binding posts on a panel. Two binding posts are for the input and three for the output. Reversing the leads from the 110-volt line has no effect on the eliminator. The total cost will be between $5 and $10 which includes the cost of the protective device. The cost will depend on the quality of the apparatus used and the amount that has to be bought. Most of the parts should be found in the average amateur's laboratory.

Getting On the Air

By A. P. Peck, 3MO, Associate I. R. E.

The Fourth of a Series of Articles Dealing With the Construction of a Short Wave Amateur Transmitting and Receiving Station Wherein the Construction of an Experimental Eighty-Meter Transmitter is described.

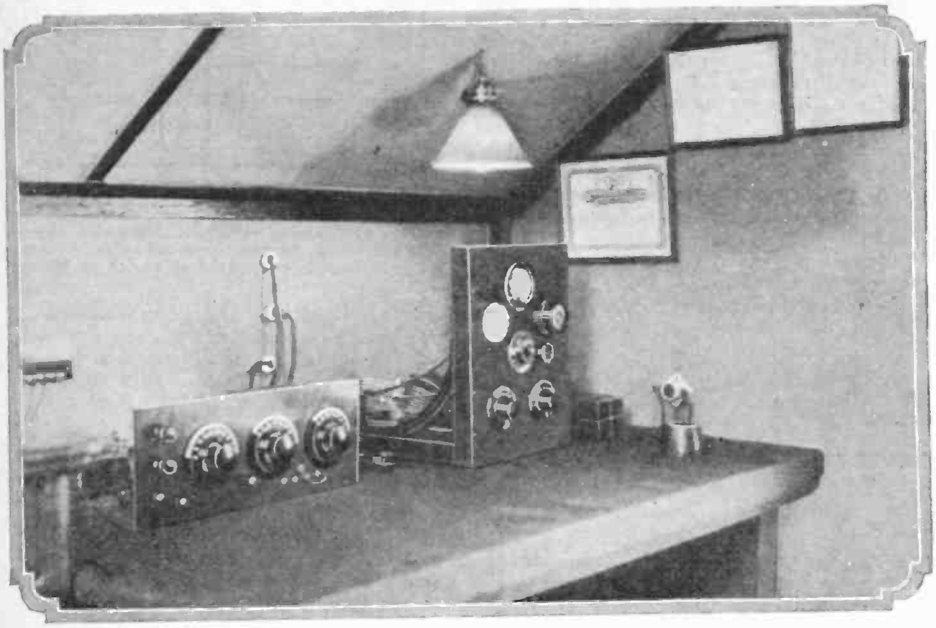


Fig. 4. Radio 3MO. Showing a corner in a well-designed and scrupulously neat operating room. The short-wave receiver described in a previous issue can be seen to the left.

PROBABLY the most difficult proposition that the amateur will encounter in "getting on the air" is the actual assembly of a complete transmitting set. In the first place, radio transmitting apparatus is hard to procure, and one cannot go into the nearest radio store and buy a complete set of parts for this purpose. Therefore, you may have to rely upon your own ingenuity to obtain certain of the instruments necessary for this work. By diligent search through many different stores and by answering numerous advertisements of manufacturers, you should in time be able to get together all the necessary instruments. A list of the parts that are necessary for the actual construction of the transmitter unit itself is given in these columns.

In this article, we will discuss only the construction of the transmitter unit. The antenna was described last month, and in next month's article the source of current for the plate supply will be described and the various methods discussed in detail. If you go about the construction of the transmitter in the right manner and take pains with it, you will just about have your unit assembled and wired by the time next month's issue of this magazine appears. Then you can go right ahead with your work in the construction of the plate supply and soon be actually on the air.

Fig. 1 herewith shows a front panel view of the transmitter at 3MO, while the illustration in Fig. 4 shows the transmitter in actual operating position to the right of the receiver. The key is attached to the table directly between these two instruments with the antenna switch back of it against the wall. The latter is of the conventional, double pole, double-throw type in which the blades have to move only through 90° instead of 180°. The plate supply apparatus, which will be described in our next issue is located at the right of the transmitter and under the table. With this arrangement, everything is handy for the operator. Reception tuning is accomplished with the left hand and the throwing of the antenna and power switch with the right hand. Of course, the right hand is also used for manipulating the key and after one once gets used to the above arrangement, much time can be saved. More will be told about the actual operation of the apparatus later.

A top view of the complete transmitter is given in Fig. 2 and a direct rear view in Fig. 3. The complete circuit of the transmitter unit is given in Fig. 5.

The main part of the tuning apparatus used in this transmitter is the oscillation coupler. It is, of what was not so long ago considered to be an obsolete style, but it

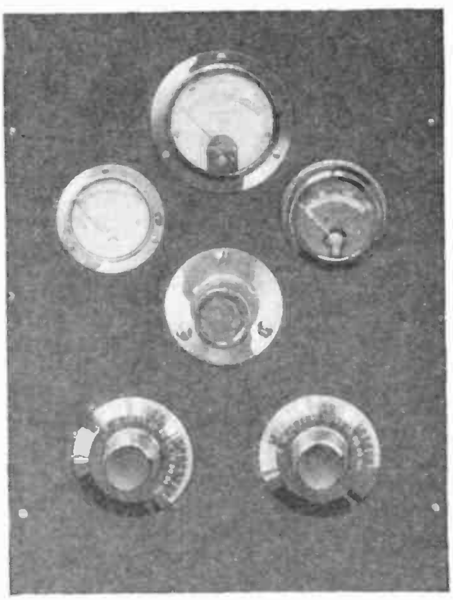


Fig. 1. Front view of the short-wave transmitter. The two lower dials are the condenser controls. The center knob is on the primary rheostat, while the two meters immediately above are the plate current and radiation meters. The top instrument is an A. C. voltmeter.

has of late been found to be an excellent instrument for short wave transmission. It can be seen in Figs. 2 and 3. Very often it is possible to pick up one of these instruments at some radio store where one happens to be in stock, but if you cannot find one, you must procure 9 turns of edgewise-wound copper ribbon, wound 7 inches in diameter and 6 turns of the same material wound 5 inches in diameter. A variable mounting block for the larger or secondary winding can readily be made following the lines shown in Fig. 3. Five more blocks of either hard rubber or well dried wood are required as spacers and are slotted so as to hold the ribbon $\frac{3}{16}$ of an inch apart between turns. All of these constructional details can be plainly seen in the photographs.

In the particular transmitter under discussion, the antenna and counterpoise leads were soldered directly to the ends of the inner or primary winding. This is not always considered good practice as it reduces the flexibility of the set somewhat, and if clips for fastening to this section are available, use them for these connections. Besides the two that connect the antenna and counterpoise, three more will be necessary for the grid, filament and plate connections on the outer or secondary coil. These clips may be connected to the other instruments by means of either heavy flexible wire or braided copper ribbon such as shown in the photos. They may be standard clips or jaws from a knife-blade switch.

Besides the two inductances just described, two variable condensers are necessary. It was found that the standard two-section Bruno condensers illustrated are constructed with ample insulation to be used on a five-watt tube with 400 volts D.C. as the plate supply. One of these condensers is connected in series with either the antenna or counterpoise and the other across the plate inductance as shown in the diagram in Fig. 5.

Meters

The average person entering the transmitting game seems to think that meters are not a necessity, but rather regards them as a luxury to be added at such time as finances may allow such a procedure. This, however, is not true, as there are at least three meters which are absolutely essential to good and consistent operation. These are an antenna ammeter, reading from either zero to 1 or zero to 2.5 amperes; an A.C. voltmeter, reading from either zero to 10 or zero to 15 volts and a plate milliammeter with a scale reading from zero to 150 or zero to 250 milliamperes. The first of these meters, the antenna ammeter, may either be of the hot wire or thermocouple type. The former is by far the cheaper and with a little intelligent care and use will be found quite satisfactory. The total price of all three of these meters if judiciously purchased need not be over $15. Anyone reading these articles who is truly interested in transmission can obtain further information on the purchase of apparatus by addressing the writer.

Fixed Condensers

In a transmitter of the kind under discussion, four fixed condensers are a necessity. Two of them are of the same size and type, one being used as a grid condenser and the other as a plate blocking condenser. They should each have a capacity of .002 mf. and should be able to withstand a pressure of 5,000 volts. The other two condensers are used across the filament circuit as shown in Fig. 5 and may have a capacity of from .1 to 1 mf. Occasionally, a single unit containing two condensers suitable for this use may be purchased, whereupon the layout of the set is somewhat simplified.

The grid leak in a transmitting set is quite as important as it is in a receiving set.

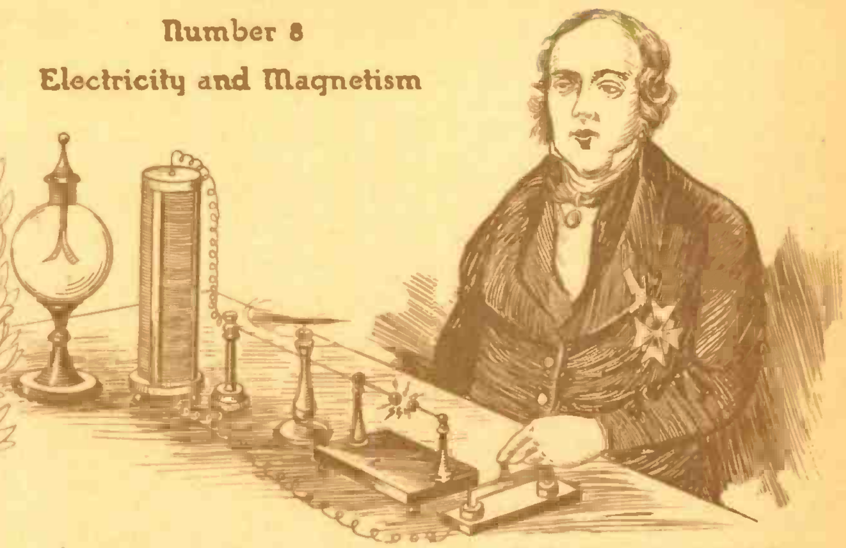
(*Continued on page 529*)

Historic Experiments

Number 8

Electricity and Magnetism

Andié Marie Ampère, 1775-1836, famous French physicist and mathematician.



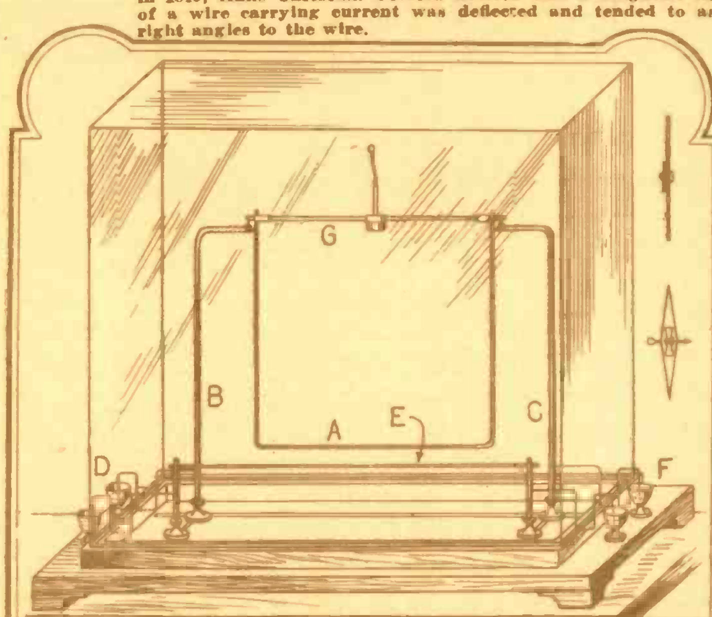
While performing experiments at a lecture in the University of Copenhagen in 1819, Hans Christian Oersted noticed that a magnetic needle in the vicinity of a wire carrying current was deflected and tended to assume a position at right angles to the wire.

IN No. 5 of this series of Historic Experiments in the March issue of THE EXPERIMENTER we saw the dawn of electrical science as such. Formerly electrical experiments had been characterized by a medieval crudeness in much of their work and what appealed to the experimenters of the time was chiefly the spectacular features of the science, rather than any accurate relation between its various elements. With Oersted's discovery of the inter-relation between electricity and magnetism, there arose a new outlook on electrical science. Oersted himself was a purely experimental scientist and his discoveries were chiefly empirical. Fortunately, however, a prominent mathematician and physicist, Ampère, became interested in Oersted's experiments and developed his researches very thoroughly.

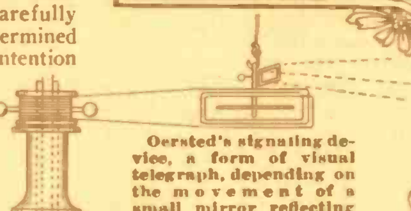
Here we have a new type of experimenter. No longer the vague groping for some unusual phenomenon, but rather a carefully planned and mathematically predetermined research. It is certainly not our intention to deprecate the value of experimental research, but we may say without exaggeration that until the time of Ampère no individual made so many fundamental contributions to the science of electromagnetism He wrote one of the most important mathematical treatises on electricity and magnetism that appeared before the epoch of the later giants of electrical science, Maxwell and Heaviside.

His investigations, however, were not purely theoretical. He performed numerous experiments to determine the validity of his theories, but as we noted above, these experiments were performed rather to demonstrate theoretically discovered principles, than to discover such principles themselves.

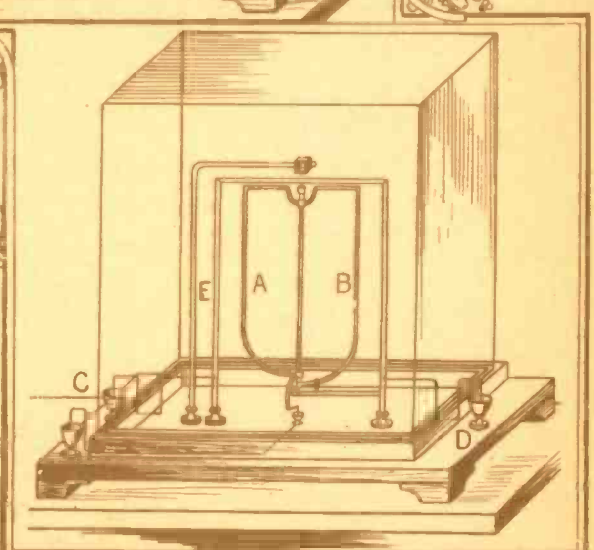
We illustrate on this page some of the apparatus Ampère employed in his work. These consisted chiefly of devices designed to investigate the inter-action between the magnetic fields set up by currents flowing in parallel wires. These experiments, which at that time seemed devoid of practical application, were the forerunners of the electric motor.



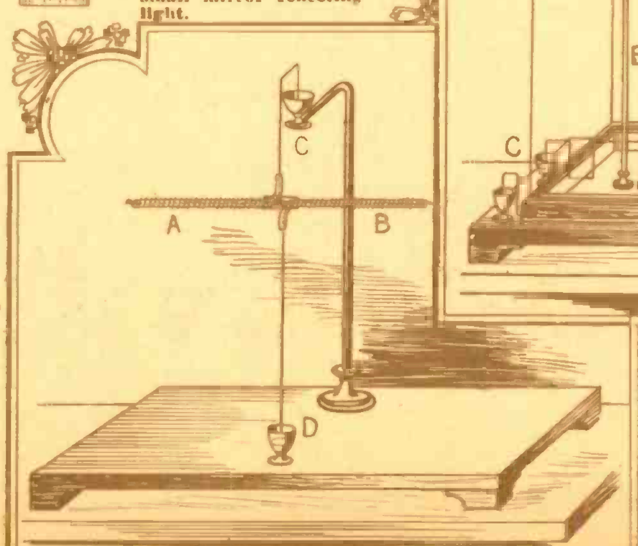
The famous French physicist Andié Marie Ampère, a contemporary of Oersted, following up the latter's experiments, studied the interaction between the magnetic fields of two parallel wires. The wires A and E can be made to carry current in the same or opposite directions. Ampère studied the magnitude of the repulsion and attraction between the two wires.



Oersted's signaling device, a form of visual telegraph, depending on the movement of a small mirror reflecting light.



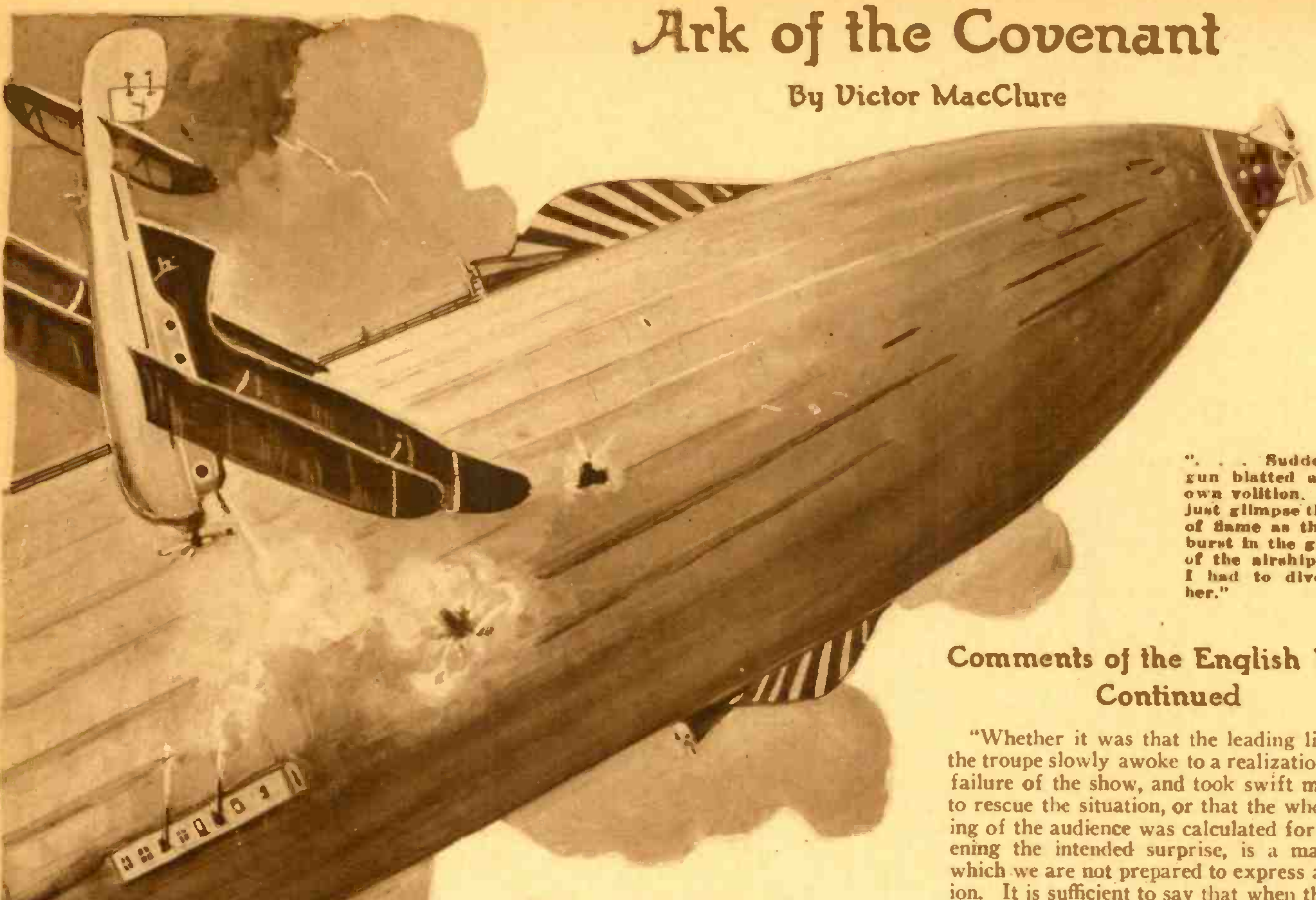
Another apparatus constructed by Ampère for studying the interaction between parallel currents. The current in wires A and B reacts with the current in the wire E.



A peculiar electromagnetic compass constructed by Ampère. The wire wound around a glass tube forming a small coil with its pivots immersed in mercury cups, constituted this unusual compass needle, as we may term it.

Ark of the Covenant

By Victor MacClure



". . . Suddenly my gun blatted as of its own volition. I could just glimpse the gouts of flame as the shells burst in the grey side of the airship, before I had to dive under her."

[What Has Gone Before]

A number of New York banks have been robbed. The time is near the end of this century. The President of one of the banks stands by his son's bedside early in the morning and tells him of strange robberies. They fly to New York in an airplane.

They find that throughout the financial district policemen, watchmen, chauffeurs and pedestrians have fallen senseless. Automobile engines have mysteriously stopped. Everything of gold, watches, coins, gold leaf signs and the like have been tarnished. The vaults of a number of banks have been cut open, apparently by oxyacetylene, and robbed.

The tarnishing of the gold is a problem for the chemist, and curiously enough, powdered glass is found in the street to add to the strange events. Little lead cases came into the Post Office by mail. Radium salts were enclosed in them.

The airplane Merlin, the fastest of all airplanes, takes an active part in the story. The mystery deepens when it is found that some millions of dollars of securities have been returned to the banks, but a slightly larger amount of gold has been taken. Anaesthetic bombs are thought of. An unheard of amount of radium salts seems to be in the lead cases. A provision store has been robbed and money left to pay for what was taken. Thousands of gallons of gasoline have disappeared from a Standard Oil Station.

They go out on the famous Merlin in search of the liner Parnassic after having vainly tried to find how the gasoline was taken from the station; they hear that there was a cabin in the air when the robbery was being perpetrated. Going out to sea, they land upon the Parnassic. Everyone on her is recovering from a trance, and eventually the Captain goes with them to the treasure safe and finds that it has been robbed.

Lord Almeric, a well preserved man of 60, joins them. The crew recovers. A discussion ensues and it is concluded that the raiders used an airplane. The Merlin starts off after the ship's engines begin to turn, taking with them the charming Miss Torrance, the niece of Lord Almeric, who is also of the party. As the Parnassic reaches port, investigations into her robbery are in order.

Now news comes that Louisville has been attacked, and an hour and forty minutes takes the Merlin to Louisville, where the New York raid has been duplicated. Next the Atlantic is crossed to Europe where similar raids have been perpetrated. The bank of England has been robbed and Scotland Yard is helpless.

The robbery of the Bank of England is investigated. Mysteriously, only a relatively small amount of gold was taken. Gasoline has been taken from the English tanks. The House of Commons was subjected to the soporific agent and when they recovered members on the Treasury bench found their faces blackened with burnt cork. The English authorities begin to realize the extent of their enemy's operations and powers and Paris and Berlin are raided on the same day. Radium left by the raiders is still a mystery.

Comments of the English Daily Continued

"Whether it was that the leading lights of the troupe slowly awoke to a realization of the failure of the show, and took swift measures to rescue the situation, or that the whole boring of the audience was calculated for heightening the intended surprise, is a matter on which we are not prepared to express an opinion. It is sufficient to say that when the other occupants of the hall woke up and found the stars of the Front Bench all confessing the real significance of their earlier efforts by having had their faces burnt-corked, a shout of laughter went up which bade fair to wreck the house. The pity is that the management did not introduce the surprise earlier in the evening.

"With a modesty not habitual in popular entertainers, however, the leaders of the troupe have emphatically disclaimed all knowledge of how the delightful surprise was worked, and even have tried to attribute the happy inspiration of the burnt-cork to the visitors to the Bank of England. In their haste to be so wonderfully modest, they have almost an air of wishing to convey the impression that their efforts in the earlier part of the evening composed a serious attempt to reduce the air services of the country. That the St. Stephen's troupe has some sort of right to discuss such an important matter cannot be denied. But if the troupe really was trying to discuss this serious national question, and really was determined that the air service of the country should be reduced, in the face of the outrage on the Bank of England—which might readily have been prevented by an adequate air patrol—their participation in the affair passes beyond a joke. It is no joke for the country to be deprived of a million pounds sterling, while black-faced minstrels occupy seats that once were filled by statesmen, and handle matters affecting the country's weal with the absurd insouciance peculiar to their kind. . .

"There has been a growing feeling throughout the country that St. Stephen's is hardly the place for antiquated forms of amusement, and that the old hall should be brought back to its one-time dignity as a chamber for the serious and considered government of the nation. Sharing this feeling, we venture the hope that this last effort on the part of the Minstrel Troupe may prove laughable enough to laugh them from their benches. Should this consummation be reached, we for one will be apt to reconsider our opinion, and regard the joke—for joke it then will be—as the only one we have ever encountered that really is worth a million British sovereigns."

The other Opposition journals did not see the affair quite that way, but they all made the most of it in their own manner. It seemed to me more than likely that the English Cabinet would be laughed out of office.

The Chase of a Great Airship and the Protection of the American Seaboard

By the time I had got through all the Sunday papers, and found that none of them had anything to add to the details Sir Thomas Basildon had given about the Paris and Berlin raids, I was due to relieve Milliken. It was close on one o'clock, London time, and perfect flying weather.

We had left the police machines far behind us, but we were passing over a British warship, to us merely a grey dot with a widening streak of white behind it. Further ahead on the sea, a series of sinister black shapes were spread out on a wide line, their wakes so definite, and the black smears of smoke athwart them so copious, that we knew them for destroyers travelling at full speed. Later, when from a grey shape below us a white fleck parted, flickering in the sun, only experience told us that the ship was a plane-carrier, and the flickering speck one of her machines taking off. But though we must have been in sight on such a clear day, we passed unchallenged. Time went on, and these ships of war lay far behind us over the edge of the sea, and only now and then would we see the squat shape of a freighter, the more graceful lines of the passenger ship—these in the slow, placid pursuit of their lawful occasions.

Noon overtook us after about four hours' flying, about two o'clock by the Greenwich time on the control-board, and after that the sun increased his lead south of us, until his angle narrowed almost to dead ahead. We kept a strict watch for the airship until after six by our clock, and giving her the amazing dirigible speed of three hundred kilometers an hour, by that time we should have overtaken her, supposing she had left Paris shortly after four in the morning. But the sky remained clear of aircraft until the time when we came upon American machines, with warships in convoy, throwing a cordon round the Atlantic seaboard.

By then we had made landfall with Cape Race, and little more than two hours later we were hovering down into Gardiner Bay, Long Island. I had a radio put through to my father saying when we might be expected and he was there on the jetty to shake Milliken and myself by the hand when we landed. The clock in the hall at Hazeldene was striking six when I sat down there for a rest and a yarn with the old man.

III

Still a Mystery Which Seems to Grow

My father listened with his usual quiet to all I had to tell.

"Sir Thomas Basildon is right," said he. "We've got a long way to go before we reach the end of this business. Well, and what do you propose to do, yourself? Is there any way I can help?"

"Yes, dad," I said, "there is. I want to get a sort of roving commission with the air police. I want to be my own master, go my own way, and work along my own lines with Danny Lamont to help me. A sort of general permit to scout about in the *Merlin*—armed to take action if I meet the raiders—that's what I'm after. Can you fix it for me?"

"I'll try. The authorities are not likely to favour any privateering, but—you're going to dispose of the *Merlin* design to the government?"

"Yes," I returned. "And that's another thing I want you to help me in. The Air Board knows me well enough—but I want speed. I don't want to be hung up in Washington for weeks, until the *Merlin* is tested."

"The *Merlin* should do the trick herself—but you'd better get straight to the President," said my father. "I can fix it for you to see him. Your reputation will stand you in good stead there, since you're not likely to be putting up any fool ideas. When can you be in Washington?"

"Tuesday morning. I'll fix up the armament belonging to the old *Merlin* on one of the new machines, and be fully prepared to show her on Tuesday. Milliken can fly the old *Merlin* at the same time, and take a mechanic or two with him. I don't want to part with the only armament I have. I might have to wait weeks for another equipment. So when the tests are over, I'll remount the guns on the old *Merlin* down there."

"I see. Then I'll write a letter personally to the President right away so that he'll have it by first mail to-morrow."

He went off to carry out this idea, while I made for the bathroom and a change of clothing.

"I have mailed the letter," said my father, when we sat down to dinner. "And if Ben Whitcomb won't do me the favour I ask him, I'll be a mightily surprised man."

"You know the President very well, then, dad?"

"We were together as struggling young men at one time, Jimmy," he replied—then with a reminiscent smile: "Golly! What a lot of fun we got out of that mighty thin time!"

I got to bed early and slept until five o'clock, when I went down to the workshops to get a start made with mounting the armament on the new *Merlin*. Milliken was on the spot when I arrived, and the first shift was getting the guns out under his direction. Dan Lamont turned up in the middle of the day, and as the work was well ahead I had time to give him the news and plans.

Letters of Marque for the "*Merlin*"

"If you get these letters-of-marque, Jimmy," he said, "you'll have to sign me on as one of the crew——"

"But what about your laboratory work, Dan? I'll be away from New York for days on end, maybe months."

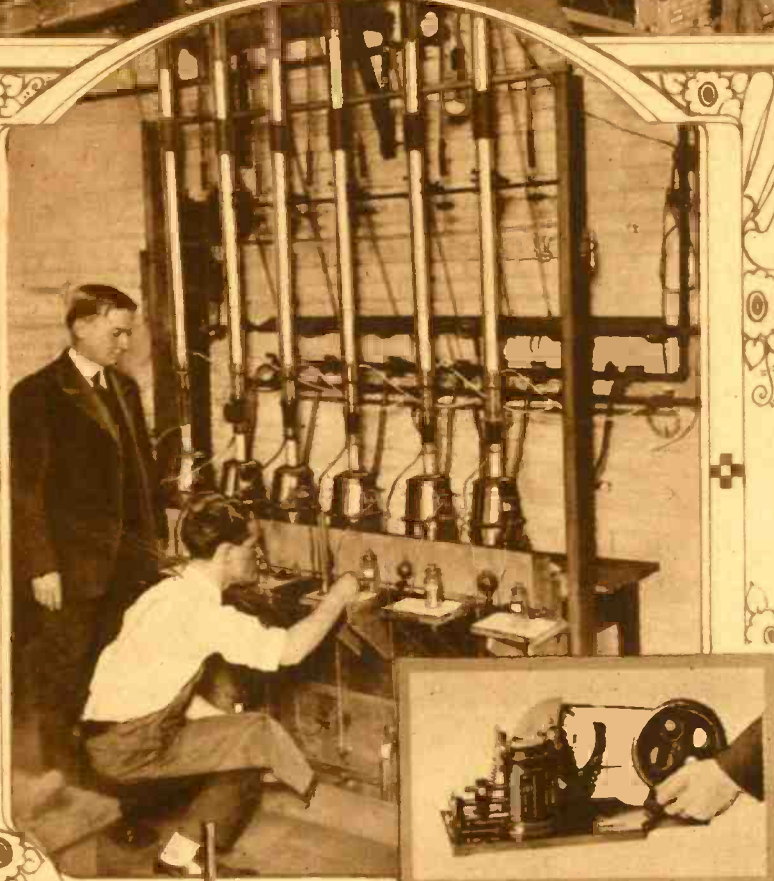
"I have to admit that this job has me beaten, Jimmy," said he. "And I don't like it. I can't get at the tarnishing of the gold, and I can't discover a gas that will do all the supposed gas of the raiders can. It seems to me that they have discovered processes miles ahead of present-day ideas, and I want to know why and how. I want to be on the spot next time anything happens, and since you're going to look for trouble, it seems to me my likeliest chance is with you. My laboratory work can wait. This thing has got me going. I particularly want to know whereabouts in the world there's enough ore to produce all that radium. You'll let me in on this, Jimmy? If I don't know anything about flying, I can easily learn to use a gun, at least—and—and —I'm pretty handy with a skillet."

(*Continued on page* 566)

"It's the ga-gas—allri," he muttered with a funny little smile. Then he seemed to crumple, and I caught him as he fell.

What Experimenters

A radio experimenter for fifteen years, Henry A. Farnham, is keeping up with the times and is here shown at his station 3ASO, well known to radio experimenters all over the country. 3ASO has been heard in Canada and in almost every state east of the Rockies. His set comprises a 20-watt transmitter operated by a 750-volt motor generator, and the conventional three-circuit receiver.

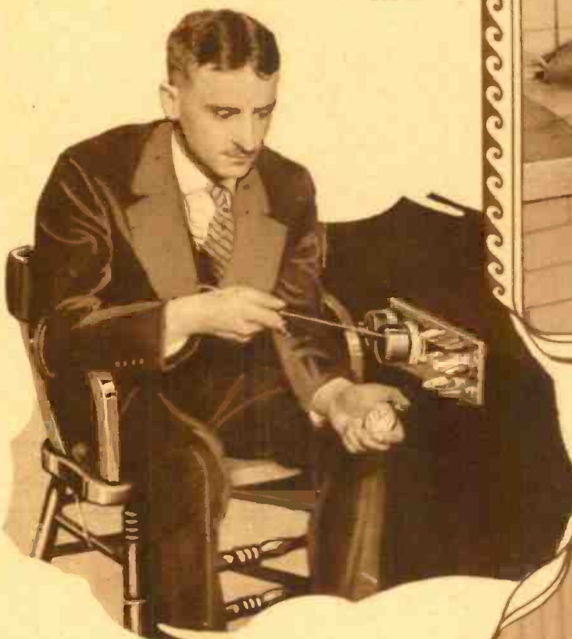


American scientists in the University of Chicago are conducting a series of experiments with the apparatus shown at the left, in an attempt to convert mercury into gold. However, by this method the production of five dollars' worth of gold will cost more than one hundred dollars.

Professor C. T. Knipp of the University of Illinois has constructed an experimental apparatus as a substitute for a more complicated one shown at the top of the picture whereby the track of alpha particles traveling at 146,000 miles per second is made visible.

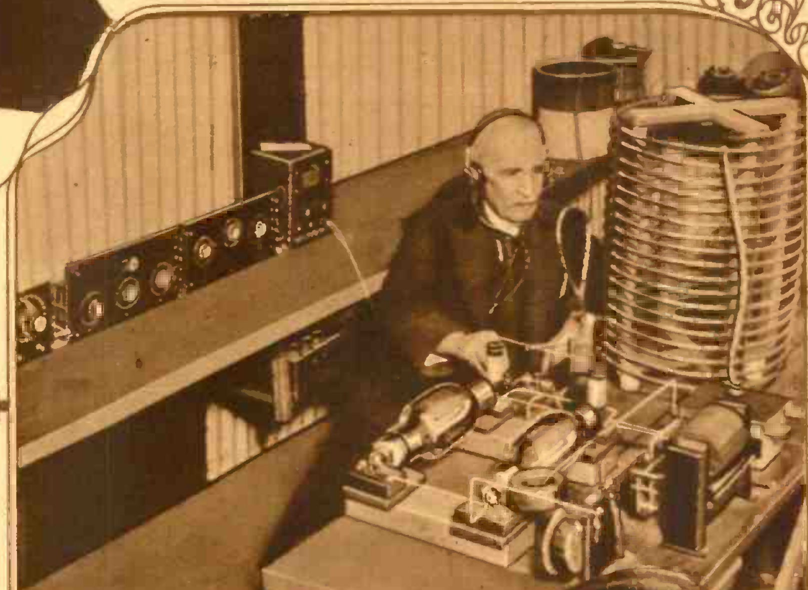
Are Doing Today

Dr. Kiess, an experimenter of the Bureau of Standards, is shown at right with some of the apparatus he used in recent observations of the solar eclipse, in which he sought for evidence of an unknown element in the sun's corona. Dr. Kiess claims to have found traces of this gas and has named it coronium.



The Snow Fear Detector, an appliance for testing an automobilist's reaction to impending accidents.

Below: The famous radio experimenter and inventor of the underground antenna system, Dr. J. H. Rogers, is shown in his laboratory at Hyattsville, Md., where for years he has carried on his radio research. Recently he succeeded in transmitting radio messages to the Pacific Coast by means of an underground antenna.



MR. SNOW has attained some prominence because of the system he has perfected, by which he claims a person's fitness to drive an automobile can be determined in advance. By means of this apparatus, the recording end of which is illustrated here, successful tests were performed with the drivers of a taxicab company of Chicago.

In this test on 307 drivers, the men whom the test revealed to be less fit for their work are reported to have had five times as many accidents as the others in a ten weeks' period The company through the operation of this system was able to reduce accidents 54 per cent., it is claimed.

The reaction of a driver in an emergency is determined by the use of an electrical apparatus which Dr. Snow calls the "fear-detector." A number of electric lights on a switchboard are connected by plugging in and the current is turned off by shifting pedals and throwing a switch when a fuse is blown out. Dr. Snow times the various operations, the driver's fitness being indicated by the time he requires to meet each "emergency."

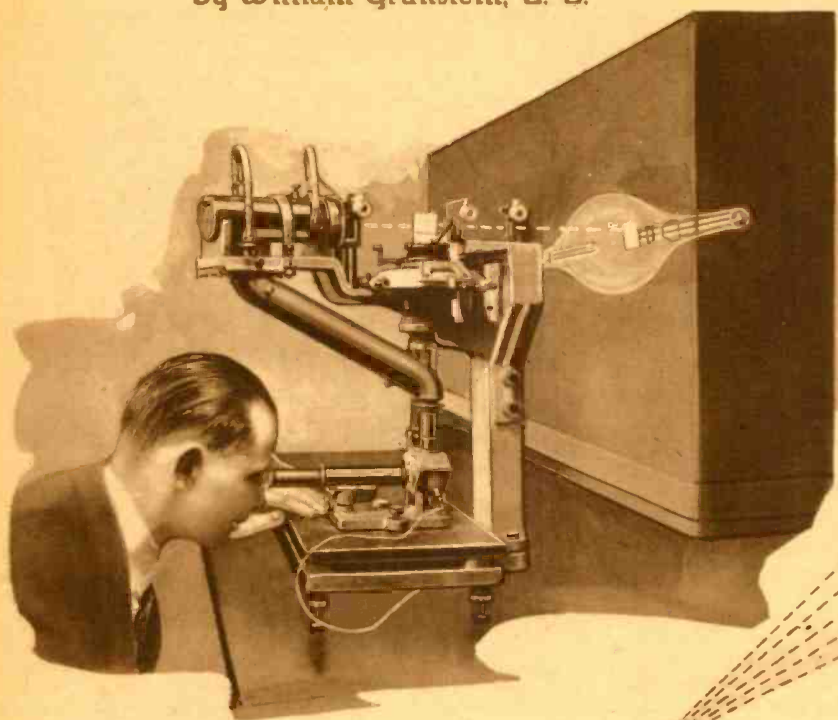
Professor R. H. Gault is here shown experimenting with a device whereby the deaf may "hear" through the hands. He claims that speech can be understood by having vocal vibrations communicated to the sensitive skin. The instrument in the foreground is the transmitter.

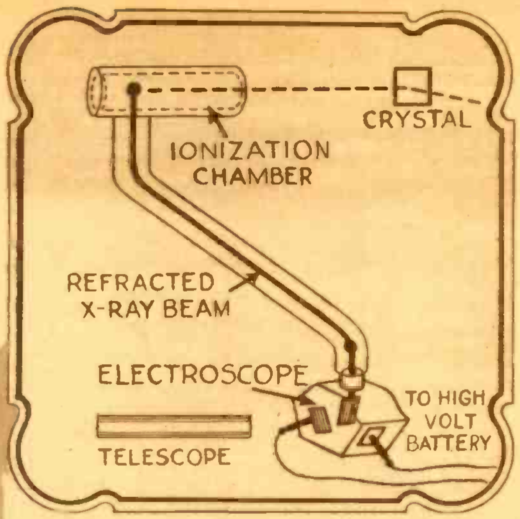
Trend of Modern Research

No. 1

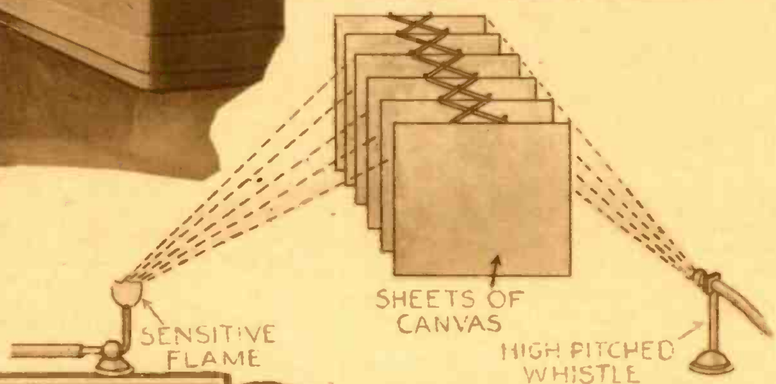
X-Rays and the Structure of Matter

By William Grünstein, E. E.





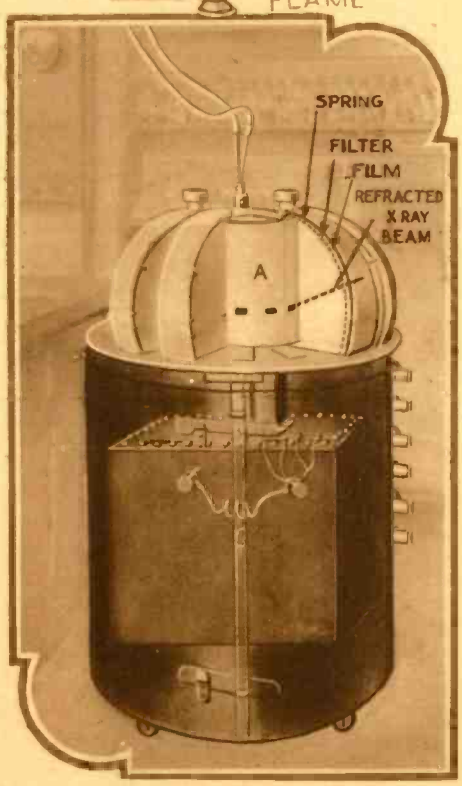
The X-ray spectroscope at the left is designed to study the arrangement of atoms in a crystal. As shown above, the X-ray is refracted by the crystal, and enters the ionization chamber, producing an electrical charge which affects a gold leaf electroscope.

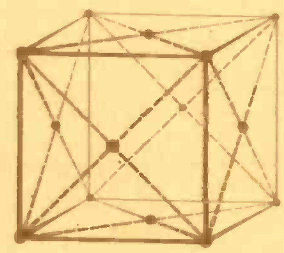


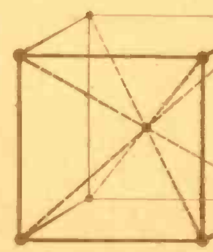
In Lord Rayleigh's experiment canvas sheets reflect the sound waves coming from a high pitched whistle. When the sensitive gas flame is properly located, the reflected sound waves reenforcing each other cause a flickering of the flame.

THROUGH a series of remarkable discoveries, the X-ray, previously in great part restricted to medical use, has become one of the most powerful instruments of research in modern physics. Because of the extremely short wave-length of the X-ray, of the order of .000,000,005 inch, they set up points of local radiation in matter through which they pass. The individual atoms of the substance through which the X-ray passes radiate electromagnetic waves of a wave-length the same as, or shorter than, the impinging X-rays. The waves emitted by the atoms will in some directions interfere with and in others reenforce each other. By determining the direction in which these waves effect such reenforcement, the structure of the crystal through which the X-ray passes can be determined. Instruments for this purpose are called X-ray spectroscope when the effect of the reinforced waves is directly observed, and X-ray spectrophotometer when a permanent record of these directions is made on a photographic film. The simple but very effective experiment of Lord Rayleigh, which we illustrate on this page, indicates a condition in sound reflection, which is exactly analogous to the refraction of X-rays by crystals, the canvas sheets employed by Lord Rayleigh corresponding to the planes of atoms in the crystal.

Much about the structure of matter has been learned by the aid of the X-ray spectroscope.

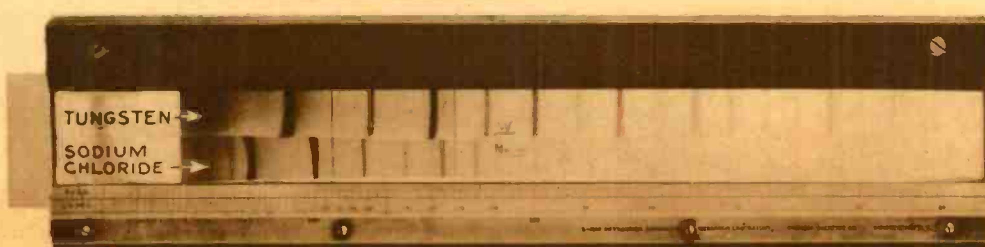






The black dots in these cubes represent the atoms of a crystal. The upper diagram indicates the structure of a "face centered" crystal and the lower one a "body centered" crystal.

This new type of X-ray spectrophotometer was designed by Dr. Hull, an American physicist, who, by the aid of a curved film, makes a permanent record of the angles of refraction of the X-ray as it passes through a small vial of the material under test. The cabinet contains a transformer used in connection with the X-ray tube.



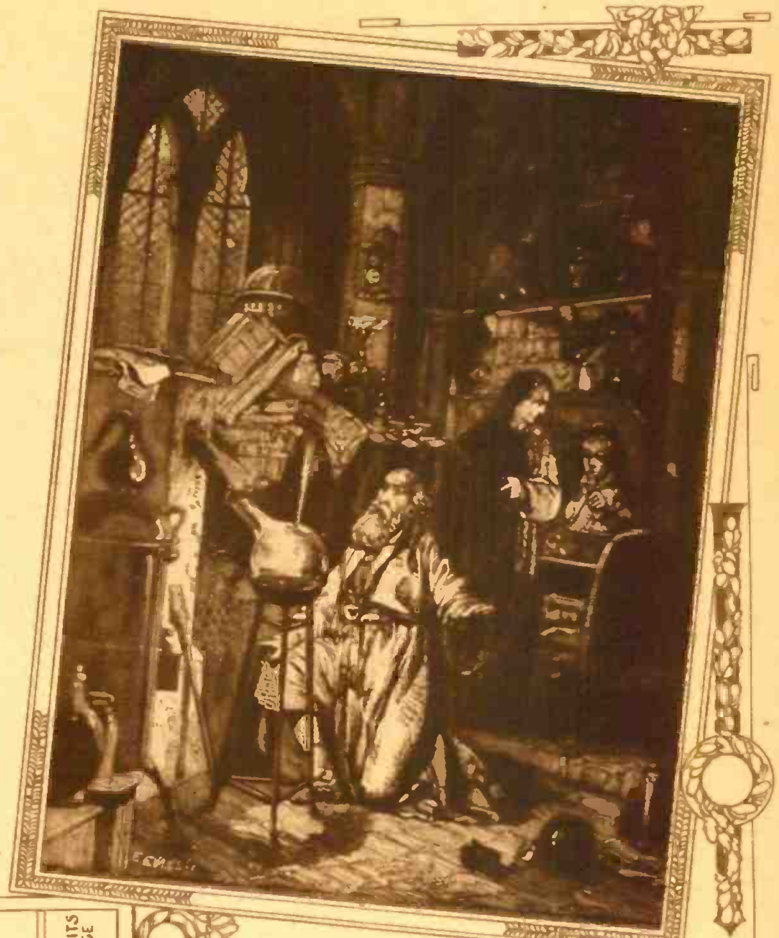
A reproduction of the photographic film after exposure in the Hull X-ray spectrophotometer. The dark lines indicate the points where the refracted X-ray beam impinges on the film. The two films were obtained by passing X-rays through pulverized tungsten and sodium chloride respectively.

Modern Alchemy

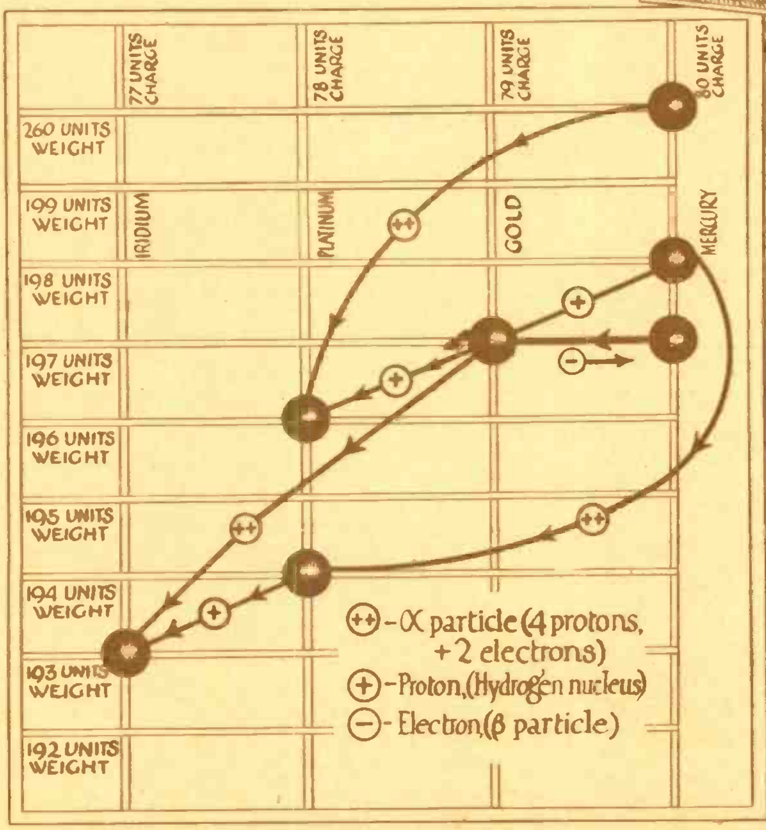
THE transmutation of metals, especially the production of gold from the baser elements, was the goal of chemists, or rather alchemists, of the Middle Ages. Since the last of these the world has for a century ceased to take attempts at transmutation of metals seriously until the recent startling results which have followed efforts in that direction. What at the dawn of chemical science seemed possible in the eyes of the alchemists again assumed an appearance of plausibility with the advent of modern chemistry. But whereas the work of these older men was largely a mystical guesswork, the modern alchemist proceeds by a method of rigorous analysis.

First, the supposedly indivisible and ultimate atom was studied and was found to be composed of even smaller particles, the so-called electrons and protons. All elements were found reducible to various configurations of these fundamental particles. The idea of altering the disposition of these particles by artificial means naturally followed from this discovery, and it remained only to carry out these conjectures in experiment, to reestablish the ideals of alchemy. This was done by a number of prominent scientists, Rutherford of England, Professor Miethe of Germany, had successfully attempted transmutation, and now the physicists of the University of Chicago are conducting extensive research along these lines.

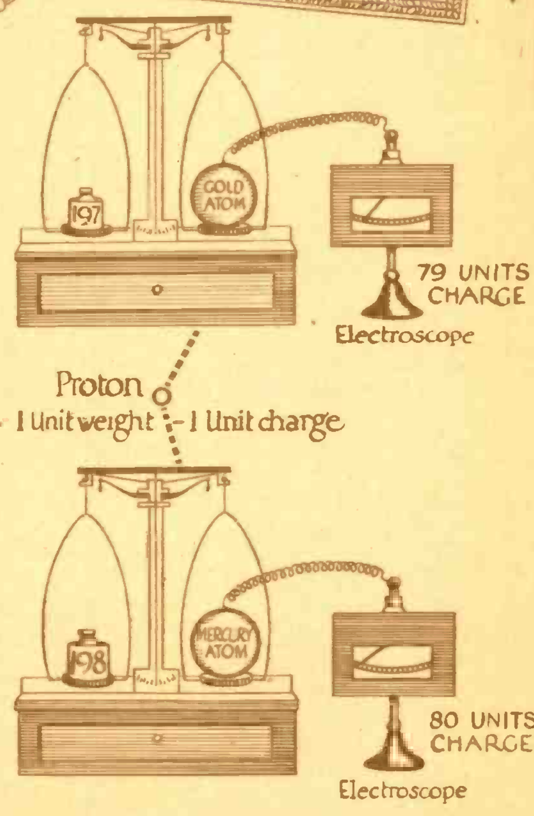
We illustrate on another page of this issue the apparatus employed at the University of Chicago.



What strange intuition led the alchemists of the Middle Ages to dedicate their life to the achievement of the transmutation of elements at a time when chemistry was so closely mingled with magic, that no accurate knowledge of the constitution of matter was possible?

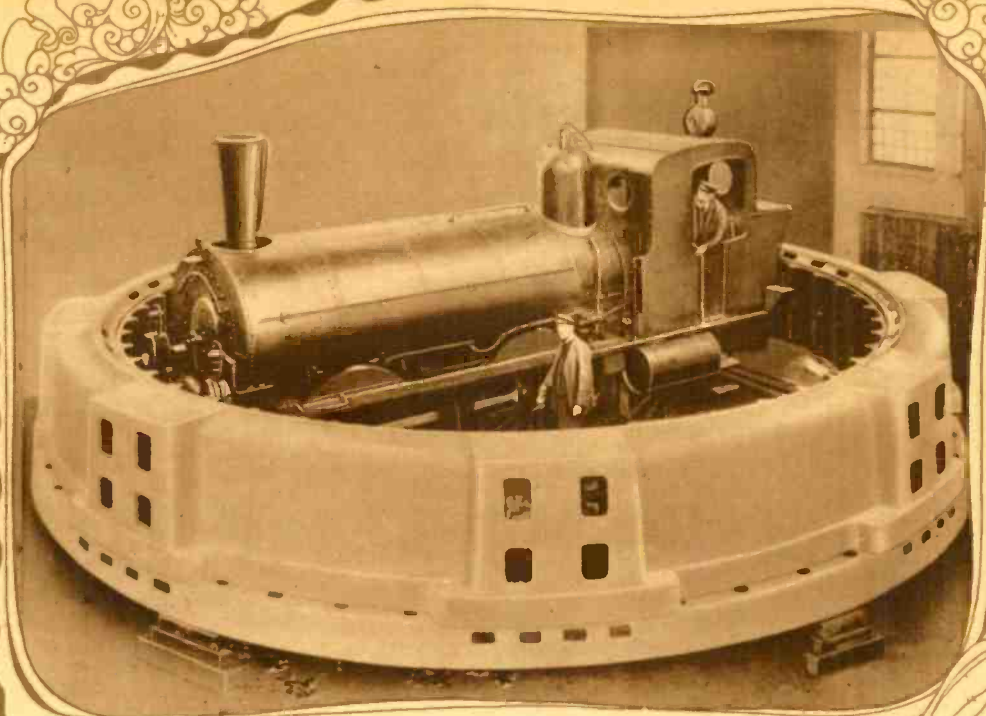


The small spheres in the diagram are so disposed as to represent the weight and the electrical charge of the elements which they symbolize. For instance, gold has 197 units of weight and 79 units of charge. This means that a gold atom has 197 protons in its nucleus and 79 planetary electrons revolving about the latter. The modern alchemist's attack is directed at the nucleus. It is claimed that by removing four protons and two electrons from the nucleus of mercury, with 260 units of weight and 80 units of charge, he can produce the very valuable metal platinum. This transmutation is indicated by one of the arrowed lines in the chart. Other changes are similarly indicated there.



Our artist's concept of transmutation. Imagine it possible to weigh a gold atom and also to measure its charge by an electroscope. It will be found that the gold atom has a weight of 197 units and an electrical charge of 79 units. If we similarly examine a mercury atom we find it weighing 198 units and carrying a charge of 80 units. Now a proton, the fundamental particle carrying a positive charge, weighs 1 unit and carries an electrical charge of 1 unit. The idea promptly suggests itself that by removing such a proton from the mercury atom a gold atom could be produced.

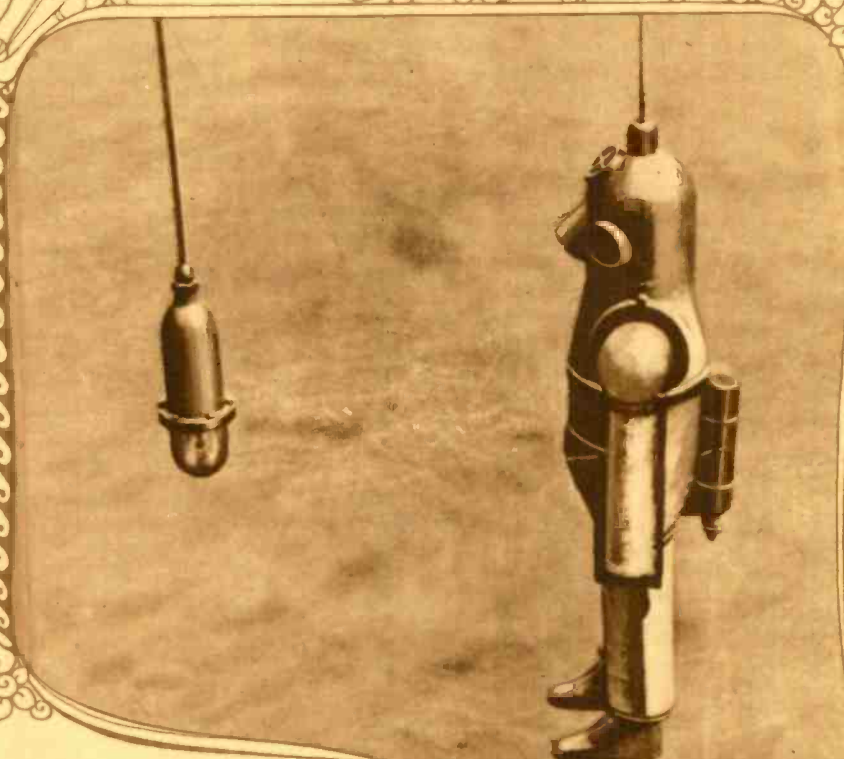
Gigantic Electric Generator

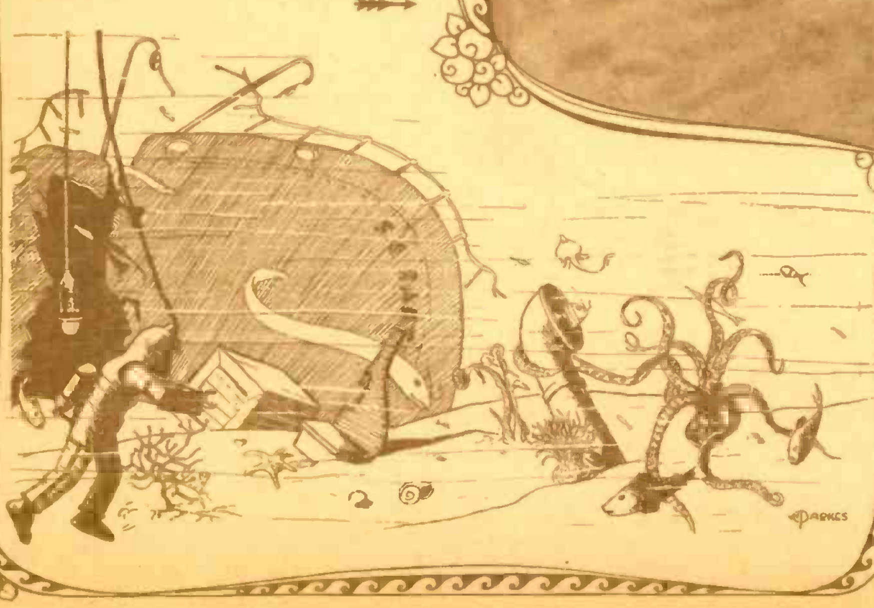


Four huge dynamos with stationary armatures such as that illustrated at right were recently installed in Leningrad, Russia, by the Swedish General Electric Company. Each supplies 8,750 kilowatts at 11,000 volts.

Neptune's Electric Lantern

The lamp shown at the right being lowered along with the diver to a depth of 350 feet in the sea is designed to withstand a pressure of 155 pounds per square inch. In recent salvage work off the coast of Chili, three such lamps were lowered with each diver. It is claimed that the lamps provide adequate illumination and that the range of vision due to them reaches a length of 25 feet.





The salvaging of treasures swallowed up in the vast depths of the ocean during the past hundred years is greatly facilitated by the construction of these undersea electric lighting units. Heretofore, salvaging has been carried on by divers in almost complete darkness.

Getting on the Air

(Continued from page 520)

However, it is of much lower resistance, being not more than 10,000 ohms, and even 5,000 ohms will be found to operate quite satisfactorily. It should be of the type designed especially for transmission and makeshifts should not be tolerated, as they will invariably cause trouble.

The tube used in the writer's transmitter is a standard C-302, and a tube of this nature gives excellent results. It should be placed in a good socket, preferably of the low loss type. The one that the writer uses is manufactured with a pyrex base and a brass shell and is very good, both mechanically and electrically.

The radio frequency choke coil connected in series with the plate circuit and used to prevent the feeding of radio frequency current into the plate supply apparatus can be seen in Figs. 2 and 3 and its connection is illustrated in Fig. 5. The one in the illustration was wound on a glass bottle, 2½ inches in diameter and consists of 250 turns of No. 30 D.C.C. wire. A wooden plug that fits snugly within the mouth of the bottle was screwed to the baseboard of the set and the bottle was forced over it. This formed quite a substantial support. The ends of the wire were fastened by using two pieces of flexible fibre with the ends clamped together as shown in Fig. 2. The bolts of the clamp form binding posts for connections and the ends of the winding are soldered to the bolt heads. In this way, lengths of fine wire are not found running from the choke coil to other instruments and the possibility of breakage is greatly reduced.

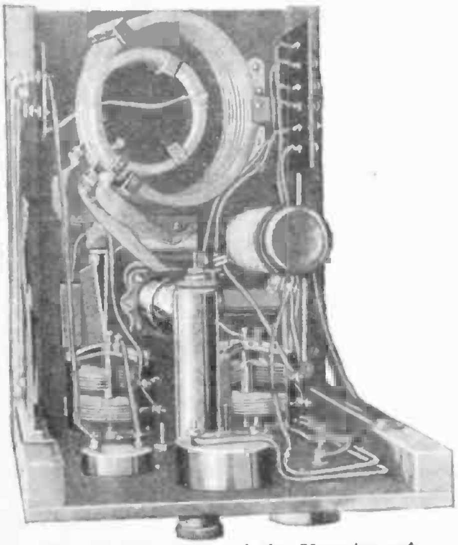


Fig. 2. Top view of the 80-meter set.

Primary Rheostat

In transmission, it is almost universal practice to use A.C. for lighting the filament of the tube. Tubes are found to give considerably longer life when supplied with this type of current. Furthermore, in the transformer used to supply this current, there is invariably a center tap used for connecting to the filament clip of the tuning inductance. This is done so as to balance the circuit and so that the A.C. hum will be reduced to a minimum. However, the former universal practice of using a filament rheostat in one connection to the filament circuit unbalanced this center tap so that it became practically useless. Therefore, primary rheostats have of late become quite popular and have been found to give perfect satisfaction.

An excellent type of rheostat for this purpose is the Bradley Radiostat which may be seen in the various illustrations and whose connections are shown in Fig. 5. The two terminals of this rheostat are connected to two binding posts on the terminal strip so that the power connections may be made at will and may be quickly changed without any inconvenience. The use of this Radiostat gives very fine control of the filament. This is most desirable as it has been found that transmitting tubes are best run at constant voltage rather than at constant current. On a standard five-watt tube, the filament voltage should never exceed 7.5 and a rheostat of this nature will keep it at exactly the value.

After all of the instruments are collected together for the construction of this set, a panel and baseboard should be procured. The method used by the writer for mounting may be plainly seen in Figs. 2 and 3. Good, strong brackets are used to support the panel. Two terminal strips, one for the antenna and counterpoise and the other for the various power leads, are employed and placed on opposite sides of the baseboard being supported by the cleats shown. By using this terminal strip method of connection, various types of power supplies may be experimented with without having to change any of the connections in the set. The layout of the instruments shown in the various photographs tends to reduce the leads of the oscillating circuits to a minimum length and therefore the efficiency is raised.

Instruments Used in Eighty-Meter Transmitter

1 Oscillation coupler.
5 Clips.
2 .0005 mf. Bruno ultra-vario condensers.
1 Antenna ammeter.
1 Filament A.C. voltmeter.
1 Plate milliammeter.
1 Two binding post terminal strip.
1 Six binding post terminal strip.
1 Bradley Radiostat.
1 5,000 to 10,000 ohm grid leak.
2 .002 mf.—5,000-volt fixed condensers.
2 .1 to 1 mf. filament condensers.
1 Garod socket.
1 UV-202 or C-302 vacuum tube.
1 R. F. choke coil.
1 Panel.
1 Baseboard.
2 Brackets.

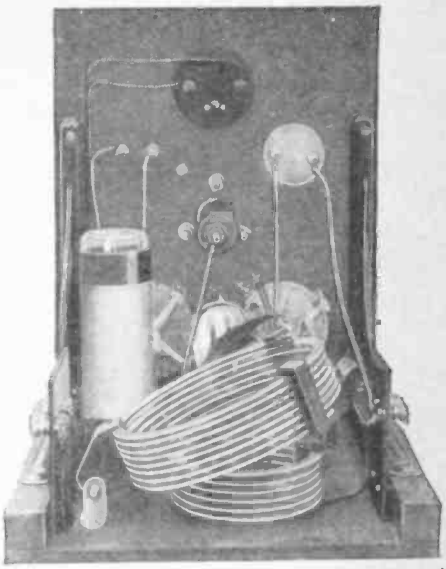


Fig. 3. Behind the panel. Note arrangement of apparatus.

When all of the instruments are brought together is the time to start the construction of the set and not before. Lay out the various instruments on the baseboard and panel rearranging them until the very best positions for short leads and symmetrical layout are obtained. Then, with these positions firmly in mind, start to mount the instruments and wire them up as you go along. If you mount all the instruments first and then try to connect them up, you may run into trouble. Therefore, only mount those instruments that go on the panel first and then place the others in position as you are ready to connect them up in the circuit. In this way you will be able to go along faster and with much less trouble than if some other procedure was followed.

So now you have a full month to go ahead with the purchasing of your instruments and the completing of your transmitting set. One reason why we do not give you the description of the power supply is because it might tempt you to rush the construction of your transmitter so much that efficiency would be reduced. Therefore, take your time about the assembly of your apparatus and use judgment and common sense in purchasing the instruments. It will pay to buy the best in the first place. With these points in mind, go to it. CUL 73.

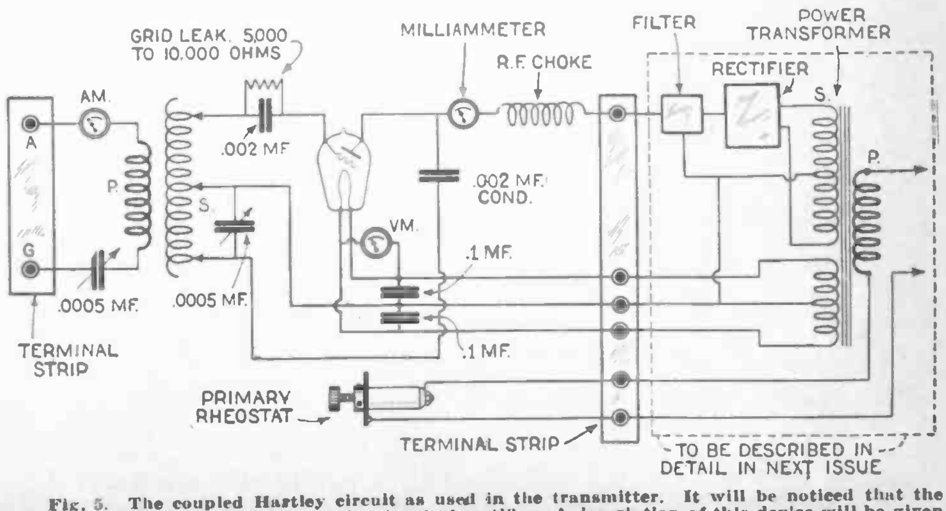


Fig. 5. The coupled Hartley circuit as used in the transmitter. It will be noticed that the plate supply is rectified by means of a chemical rectifier. A description of this device will be given in the next article. The primary rheostat works very effectively in controlling the filament current.

Experimenting with Cone Type Loud Speakers

By C. K. Fankhauser, Jr.

FOR the experimenter who is interested in improving the quality of reproduction received from radio loud speakers, practical designs and instructions for two types of cone loud speakers that give unusual results are offered here.

Anyone who has listened to the average horn type of loud speaker is familiar with its deficiencies. It will be found that the cheaper ones sound "tinny" and do not reproduce all of the tones especially missing the lower ones. Distortion is frequently found. And even in the best and most expensive ones there are faults. The horn type, by reason of its very form, is particularly unsatisfactory for orchestral selections. The sound is thrown out in a concentrated blast, and is very loud to the listener directly in front of the horn and distorted to one not in front, and it will not reproduce drums and other instruments of low tones.

A loud speaker that eliminates the concentrated blast of a horn reproduces all of the notes faithfully, and radiates the sound in all directions is that known as the cone type. While the ones on the market are very expensive, one may easily be constructed at a cost of approximately five dollars, the chief item of expense being a Baldwin phone unit.

There are two types of cone speakers, one using two cones of parchment paper and the other using a single cone of membrane such as is used for drum heads. The former is shown in Fig. 1 and the latter in Fig. 2.

First let us consider the one shown in Fig. 1.

To construct the cones proceed as follows:

From one piece of parchment cut a circle 18 inches in diameter and cut out a fan-shaped segment as shown in Fig. 4. The width of this segment should be 2 inches at the circumference of the circle. Cut the second piece the same diameter; cut a hole four inches in diameter in the center as shown by dotted line in Fig. 4; then cut from center to edge in a straight line.

Draw the edges of the open segment of the first piece together and glue a strip of paper on each side or use half inch adhesive tape. This will form the front cone. Now, lapping the edges of the cut in the other piece, place it against the front cone and draw together until the edge is about one-eighth inch inside of the circumference of the front cone, mark the amount of lap-over, and cut a fan-shaped segment out to that size. Then fasten the edges as was done with the first cone. The two cones are joined at their circumferences with glue.

From a piece of thin sheet copper cut two circular, flat rings one-half inch wide, with the inner diameter four inches. Drill several small holes for No. 6-32 machine screws, placing the two rings together while drilling to match holes. One of these rings is then placed on the inner side of the opening at the back of the cones, and the other on the outside, the two are then bolted together. Four of these screws should form the corners of a square and they should be at least an inch long for fastening the cones to the support.

At the nose of the front cone is an adjusting nut and support marked (M) in Fig. 1. A detail of this is shown in the diagram.

To construct this, cut a piece of one-fourth inch brass rod about three-fourths of an inch long and square on the ends. Drill a hole just large enough lengthwise through this to admit the hard drawn wire that is to be used between the Baldwin unit and the cone. A piece of square bus wire was found very satisfactory. Then drill and tap for a small set screw as shown in the illustration.

From a scrap of thin sheet copper cut a circular piece about two inches in diameter and cut from this a fan-shaped piece as shown in the detail. Drill an eight-inch hole in the center, center the piece of brass rod on this and solder carefully. Then bend the blades of the fan back to an angle that will correspond to that of the sides of the cone. Cut an opening in the nose of the front cone to admit the piece of brass rod. Roughen the face of the fan with emery, apply glue and fasten it to the inner side of the nose of the cone with the brass rod protruding as shown at (M), Fig. 1.

The next problem is to prepare the Baldwin unit. As this was designed to operate

(Continued on next page)

The materials needed are as follows:

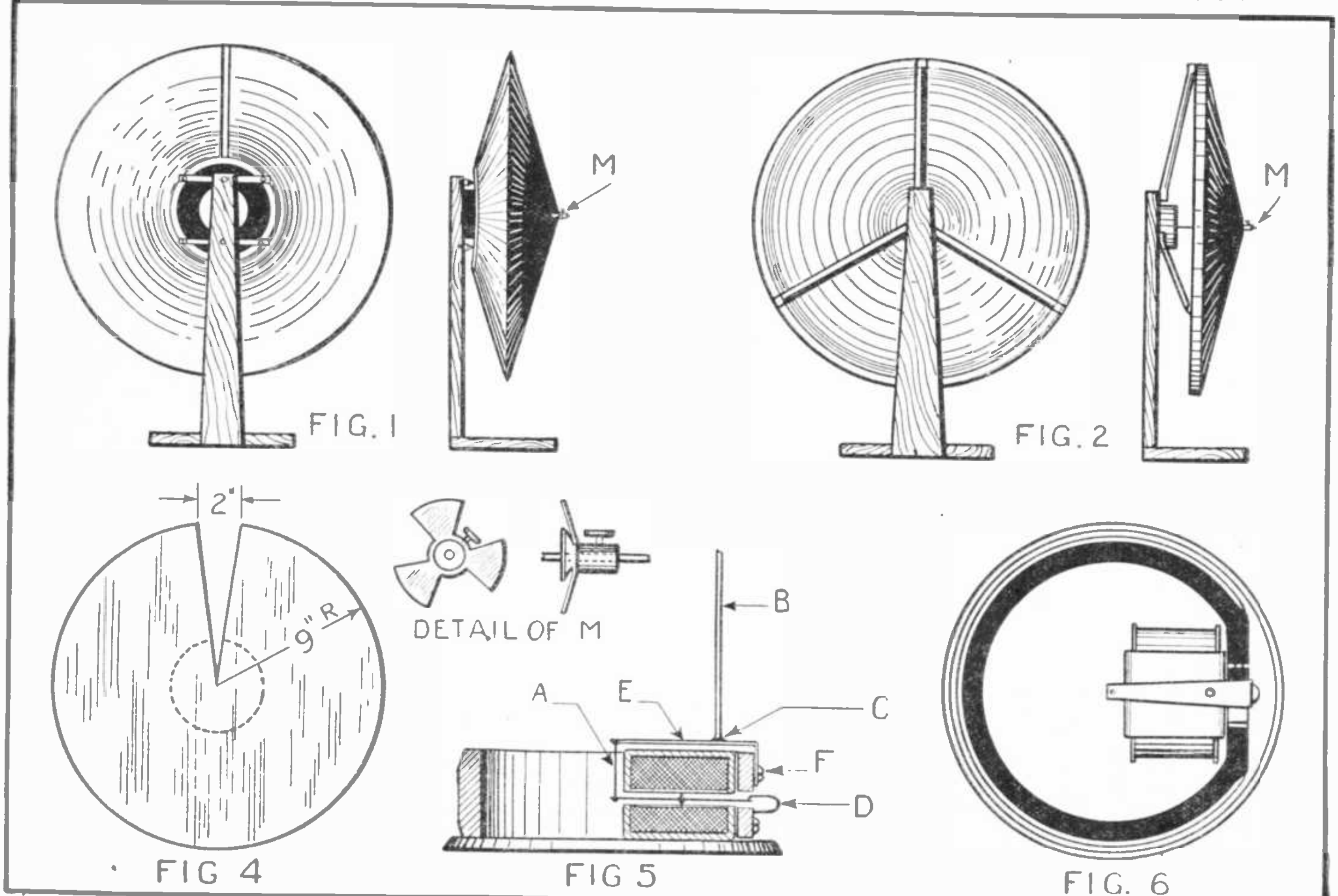
One Baldwin unit.

Two sheets of heavy parchment paper of the kind used for lamp shades or two sheets of blotting paper, each at least 18 inches square.

Wood for base and support as shown in drawing.

One length of square bus wire or hard drawn copper wire of the same size.

Some sheet copper, a small piece of thin spring brass, one inch of quarter-inch brass rod, screws and nuts.



Constructional details of two types of paper cone speakers. The one shown at Fig. 1 has a closed back and the one at Fig. 2 an open back. A Baldwin phone is used as the loud speaking unit.

My Experiences with the Colpitts Circuit

IS radio frequency amplification worth while? Do any of the readers using such sets, one, two or three step get further than a thousand miles very often? You are one of a very small number if you do.

Well, I have a little ordinary regenerative set that works up to about 1,700 miles every night. The set, known as the "ultra-audion," consists of an inductance, fixed or variable, a variable condenser, tube rheostat, socket, batteries and phones. The inductance may be a one slide tuning coil, a tapped coil, a fixed coil of about seventy turns, or a variometer, the forty-three or twenty-three plate variable with a vernier. The advantage of the vernier may be seen from the fact that about six or seven stations may be tuned in and out by merely rotating it through 180 degrees. It is also desirable to use a vernier rheostat as the tube oscillates easily. The circuit is shown in Fig. 1.

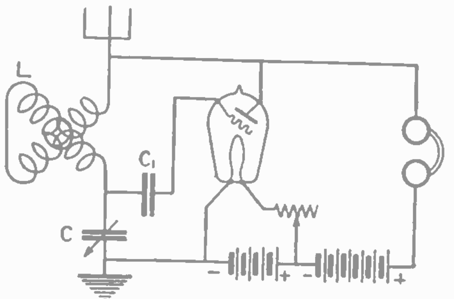


FIG. 1

The familiar ultra-audion circuit with which excellent results in the reception of distant stations have been obtained.

The inductance, if variable, and the condenser should be set approximately for the wave-length to be received, the fine tuning then being done with the vernier. It will be found that the large condenser should be set near zero when receiving short wave stations.

Here are my results which may interest your readers:

KPO	1915 miles—San Francisco, Calif.	Clear, but faint.
KGW	1815 miles—Portland, Ore.	Very good, like a local.
KFI	1780 miles—Los Angeles, Calif.	Fairly loud, heard regularly.
KHJ	1780 miles—Los Angeles, Calif.	Loud, heard often.
CFCN	1430 miles—Calgary, Canada.	Weak, but heard often.
PWX	1300 miles—Havana, Cuba.	Very good, like a local.

A total of 111 stations were received, every one being heard on a single bulb, the one step of audio amplification being used only when more than one person was listening. Proof that my location in Maywood, Ill., is not responsible for my success is shown by the fact that a friend a block away from me using the same type of set with one WD-11 tube has heard KHJ, KGW, KFI, PWX, and about fifty others.

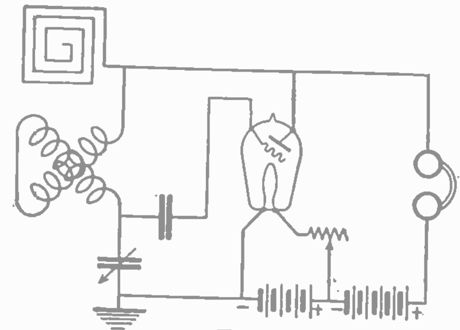


FIG 2

The same circuit shown in Fig. 1 using a loop antenna. Note that the connection is uni-lateral.

If, when using this set, any trouble is experienced from interference, it can easily be remedied by the use of a wave trap.

The set is well adapted for experimenting as the type of aerial is not critical. Using a two-foot loop consisting of ten turns of No. 18 D.C.C. connected as shown in Fig. 2, I have had but little trouble in picking up KDKA, WWJ, WSB and WOC.

Using fifty feet of bell wire buried two inches in the snow, I was able to get WBAP, KFEL, WGY, WWJ and WSB. Using the same wire strung ten feet above the ground, I was able to get KHJ and KFI.

Contributed by WALTER JOHN RABE.

Correction Notice

The Radio Data Sheets in last month's issue, May, were numbered incorrectly due to an oversight. Sheet 1-6 should have been back to back with sheet 1-7. Sheet 10-5 was incorrectly numbered and should have read 10-6. Also, sheet 14-10 should have been opposite to 14-11. The above corrections should be made by all readers keeping the Data Sheets as reference.

Experimenting with Cone Type Loud Speakers

(Continued from preceding page)

a small mica diaphragm, some changes must be made to adapt it for the increased size of the diaphragm it will be called upon to move.

Remove the unit from the case. Unsolder the pin at the center of the mica disk and remove the disk. Also unsolder and remove the small pin running from the movable armature of the unit to the center of the disk. A reference to Fig. 5 will make this clear. This illustration shows a cross section diagram of the unit. Now, from a piece of thin spring brass, cut a piece that is about three-eighths of an inch wide at one end tapers to one-eighth and is about two inches long. This piece is shown at (E), Fig. 5. Remove the screw (F) that holds the upper pole piece in place and drill a hole in the widest end of the strip of brass to admit this screw. The strip is now put in place and held by the screw. It is then bent at right angles so that it will clear the top of the coil about an eighth of an inch and is allowed to protrude slightly over the center of the unit. Cut off at that point.

Now replace the pin first removed from the unit with a small, ordinary brass pin as used in general. But this time the pin extends from the movable core towards the back of the unit instead of to the front as before. This is soldered with a very small drop of solder to the movable core and to the small end of the brass strip (E).

Now at a point about two-thirds of the distance from the pin to the large end of the brass strip, solder a length of bus wire about eight inches long, being careful to get it perpendicular to the strip. This is shown by (B) and (C) in Fig. 5. (D) is a small spring used in balancing the movable element in the center of the hollow core of the magnets of the unit. Until the loud speaker is assembled and adjusted this spring will tip the movable element so that it lies at an angle in the hollow core.

The unit is now fastened near the top of the support with a screw through one of the several holes drilled through the aluminum plate upon which the permanent magnet of the unit is mounted.

Strips of bakelite or fibre are fastened to the support and properly spaced and drilled to take the four bolts which pass through the copper bands lining the large hole at the back of the cones.

To assemble, loosen the adjusting screw at the nose of the cone, pass the piece of bus wire soldered to the unit through the drilled hole in the nose piece and bolt the cones to the cross arms on the support.

To adjust, the nose piece must be moved along on the rod of bus wire until the pressure exerted by the cone is just enough to counteract the pressure of the spring (D) in Fig. 5. When this point is reached, the flat movable element of the unit will be centered and parallel to the side of the hollow core in which it moves. If it touches either side the phone will not operate. As changes in atmospheric conditions will alter the tension exerted by the cone, it will be necessary to adjust this occasionally. The bus wire rod is now cut off, leaving about a quarter of an inch for adjustment.

The real difference in the type of loud speaker shown at Fig. 2 is that only one cone is used and a different material composes the cone. For the latter secure a drum head approximately eighteen inches in diameter. This can be obtained from any musical supply store. It will be found to have a narrow wooden rim around the edge on which it is mounted. This should be reinforced with fairly heavy sheet brass. This can be cut out in arc segments of the proper width and fastened to the wood rim with small brass screws.

If the membrane obtained seems too heavy, it may be thinned by sanding the rough or reverse side very carefully with fine sandpaper. If this is attempted, great care must be taken not to make it thinner in some spots than others and not to sand through the membrane.

The membrane may be stretched to a slight cone shape by placing the nose piece of the same type as that used in the parchment speaker in place, attaching a piece of hooked bus wire extending to the outer or front side, supporting the rim and hanging a small weight on the hook.

The rim of the membrane is supported by three arms of wood as shown in Fig. 2. The other parts and the adjustment are the same as for the first described speaker.

For experimental purposes, once the Baldwin unit is properly altered and mounted, a number of cones and diaphragms of various materials may be constructed and interchanged to determine the best type.

Some Good Reflex Circuits

By J. R. Balsley

IT SEEMS that the popular demand for a low-priced, long-range, easily-operated receiver has not been met satisfactorily by any device so far described in any of the radio magazines.

Super-regenerators are far from satisfactory for reception of music because of the distortion that is an inherent feature of this type of receiver. Furthermore, they depend

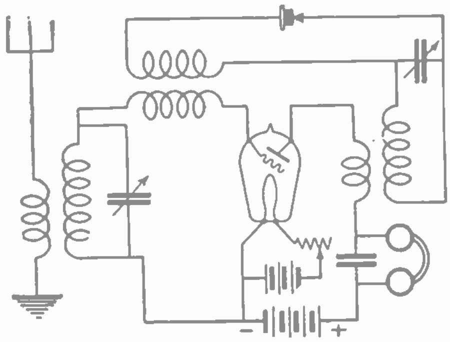


Fig. 1. A one-tube reflex receiver using a crystal for detector. Volume is good and distance greatly increased by the addition of the reflex system.

on strong oscillations of the close-coupled antenna circuit to produce results and this creates a disturbance in all nearby receivers.

The reflex type of receiver seems to be the one with which we may expect to accomplish the greatest results with the minimum of parts. Many experimenters have constructed single tube reflex receivers that produce the desired results, but unfortunately the majority of them are discarded as unsatisfactory for one reason or another.

Almost any single tube reflex will amplify signals within 30 or 40 miles sufficiently to operate a loud speaker, but most of them fall down miserably on DX work simply because there has been no good method suggested for reducing the antenna resistance sufficiently to pass very weak signals.

The most effective method for practically reducing the antenna resistance is, of course, through regeneration. Using a feed-back coil in the plate circuit of a single tube reflex is very unsatisfactory, because the tendency of the tube to oscillate at the high incoming frequencies makes the set very unstable. Using a set constructed as in Fig. 1, great care must be taken to keep tuner (A) and transformer (B) out of inductive relation to insure stability even though the damping effect of the tuned crystal circuit tends to make the set more stable. Capacity between carelessly arranged wires will often cause the tube to oscillate. Except with a very good antenna, this set is not satisfactory for DX receiving without some method for reducing the antenna resistance. Inasmuch as great care must be taken to construct the receiver as described, it is evidently almost impossible for the average experimenter to introduce regeneration in the usual way and get results.

The set described herein will, I believe, make it possible for any experimenter to build a really good single tube regenerative reflex receiver. There are no original ideas introduced, and it does not have to support a triple-expansion, cross compound double-acting, ultra, super, some kind of a dyne name, so I believe it will be looked upon with favor by the builder who has to watch his expenditures.

The tuner is built with a split secondary which would normally cause the tube to oscillate at all times were it not for the small balancing condenser which makes it possible to control oscillations under any circumstances, and therefore gives the set stability. The grid-plate capacity of the UV-199 tube is .0000042 mfd. and of the 201-A tube is .000009 mfd. so that any small variable condenser with a range of 1 to 10 micro-microfarads will be satisfactory and the tube may be kept just below the point of oscillation with a (C) battery in the grid return, thereby making possible amplification at both radio and audio frequencies.

The secondary of the audio transformer may be connected in series with the input coupler as in Fig. 2 or in parallel as in Fig. 3. The last named is the suggested

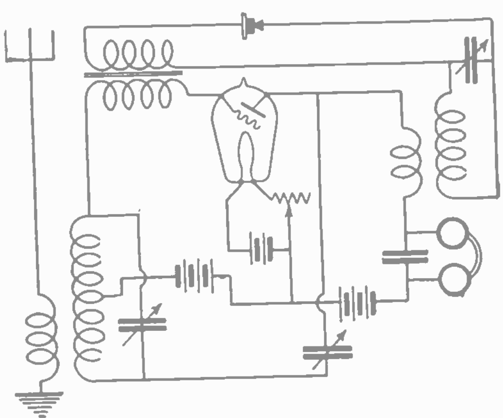


Fig. 2. Another method of reflexing using one tube and crystal detector. The primary is semi-aperiodic, the secondary is 60 turns tapped at the 30th turn. Both variable condensers are of .0005 mfd. capacity.

method inasmuch as tests have shown this to be the most efficient. In the parallel connection it is necessary to insert a choke in the audio circuit, otherwise the secondary of the coupler would be short circuited due to

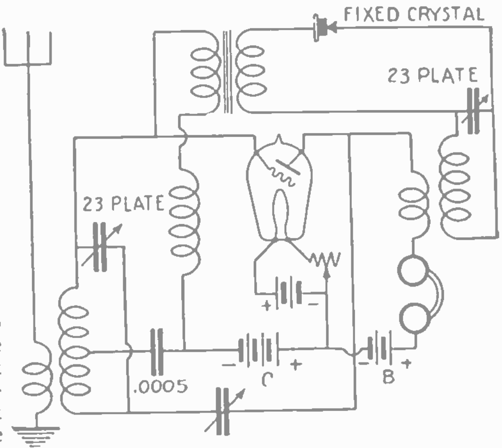


Fig. 3. Another one-tube reflex circuit. This circuit is very selective as well as being unusually sensitive. Both condensers are 23-plate (.0005 mfd.). In connection with a good aerial and ground system very good results may be obtained from any of these circuits. A hard tube is used in each circuit.

the capacity between windings of the audio transformer. It is also necessary to insert the small stopping condenser shown to keep from short circuiting the audio transformer.

The tuner and transformer should have about 10 turns on the primary and 65 on the secondary if wound on a 3-inch form. The secondary is wound first and the primary is wound directly over the secondary separated by a piece of waxed paper. I used No. 28 SCC wire. To make a neater job, buy two neutroformers which will be exactly right.

Mount the two coils on the rear plates of the condensers and place their axes at right angles. By this method the entire set may be built behind a 6-inch by 7-inch panel.

Here at Green Bay, Wis., both coasts are heard regularly, and it is possible to hear the Chicago stations (125 miles) on the loud speaker using an (A) tube with 90 volts on the plate. KDKA comes in sufficiently strong for the loud speaker every night, and WBZ has been heard several times almost as loud as the Chicago stations. One of these built for a friend in Philadelphia, Pa., has proved very satisfactory, and he reports having heard the Pacific coast on several occasions.

A French Precursor of Radio

By M. Guinchant

IN his work on experimental and mathematical physics the famous Biot, writing in 1816, described the two following experiments:

On page 454 we read: "Hang by a silk cord a living frog at some distance from the conductor of an electric machine and fasten to one of its legs an extremely light and flexible metallic cord which will make connection with the earth; then turn the machine, and as electricity is developed, draw sparks from the prime conductor from time to time by holding near it a metal rod ending in a hemisphere.

"At each discharge you will see the frog tremble, although he is not in the arc of communication; his natural electricities which the influence of the electrified conductor separates, suddenly join every time this influence is destroyed, and excite motion in the organs of the animal.

"These effects are produced even after death; to see them in all their strength we must suddenly kill the frog by cutting his body in two, after which he is skinned and prepared. Then the irritability is such that the muscular contractions are produced at a distance of ten or twelve meters" (32½ to 39 feet).

We may be led to believe, from this little story, that Biot discovered a form of wireless as far back as 1816. The fact that the sensitiveness was such that the muscular contractions were produced at distances of 30 to 40 feet may not necessarily have been due so much to the irritability of the muscles as to a special type of power transmission. Biot may have been the real discoverer of radio, but did not realize it.

If the preceding story is true, it would certainly be interesting to know exactly along what lines Biot had experimented in his wireless transfer of energy. If more could be learned of Biot's experiments along this line, the day may be in the very near future when we shall have our entire power requirements transmitted by radio.

Increasing Inductance Efficiency

By Abner J. Gelula

INDUCTANCES are, unfortunately, more or less underestimated as to their value in the circuit. Whether the coil is used for the transfer of energy or merely to control the incoming energy is a very important factor in radio reception.

It seems to have become a popular belief among radio men that as long as an inductance is air-wound or wound in some fantastic manner, it must be low loss. Before we can speak intelligently upon the ideal types of coils, we must visualize the ideal in inductances.

There are many very good low loss coils on the market today. However, none of them are, in an absolute theoretical sense, wholly low loss. From our present point of view an absolutely no loss inductance is im probable.

A purely no loss coil would have to be wound with a substance that presents no resistance to the incoming electrical current; it would have to be positively outside of all interacting fields; it would have to be wholly inductance and have no capacitive action. Let us consider, from a technical point of view, the various known types of inductances.

In the year 1919, the most efficient tuning instrument operating upon the induction principle was the loose-coupler. Even as late as that year, comparatively little thought was given to electrical losses; the entire engineering faculty was bent upon making an instrument of excellence purely from a mechanical point of view. Certainly, the loose-coupler of that day was a beautiful instrument to look upon, but under actual test the instrument showed an effective resistance of 24 ohms! Compare this with some of our modern day inductances which have a resistance of approximately five ohms.

The idea, in modern design of coils, is to secure the greatest amount of inductive energy per turn, also to bear in mind reduction of loss due to the distributed capacity. The spider-web coil and the stagger wound coil are similar. The stagger wound coil seems to be used more generally when the forms are removed, as this type of winding brings about a more stable coil, mechanically. The stagger wound coil may be wound at home without much trouble. Procure 15 dowels each a quarter of an inch in diameter. Fifteen holes are drilled, in a circle 3½ inches in diameter, on a 4 x 4 x 1-inch board. The holes are drilled with a quarter-inch bit, as they are the receptacles for the dowels. Fig. 1 illustrates this very effectively.

For winding the coils the question is always raised as to the best insulation for the wire. Doubtless, the best type of insulation for inductances is enamel double-silk covered. Laboratory tests have proved that double cotton-covered wire and double silk-covered wire are approximately equal as to results. In damp climates the cotton-covered insulation is likely to become moist and to lose its insulative qualities. This is not as probable in the case of the silk insulation. However, the cotton-covered wire creates a greater space between turns and thus to some degree cuts down the distributed capacity.

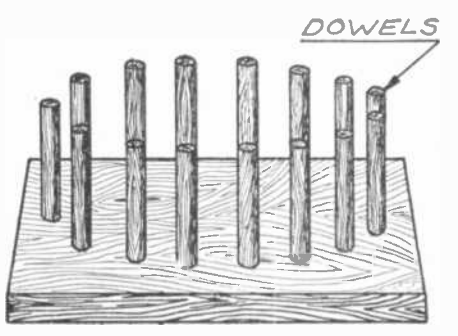


Fig. 1. Fifteen dowels are arranged in a circle 3½ inches in diameter on a square baseboard 5 x 5 inches. To wind the basket-weave coil, for which this form is used, the wire is wound in and out of the pegs, in an alternate manner. The pegs are approximately one-quarter inch in diameter.

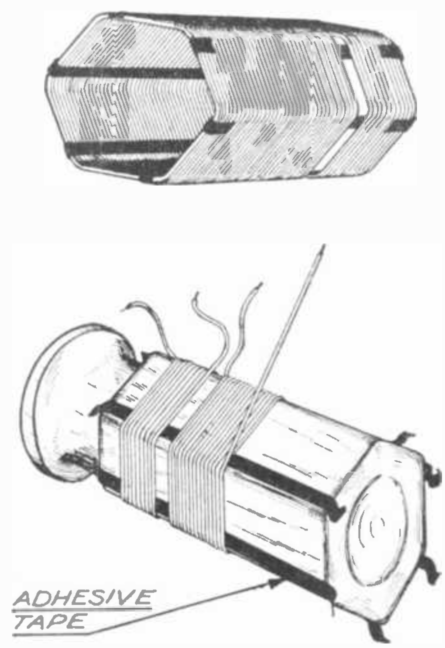


Fig. 2. The two drawings shown above indicate how a pickle-bottle coil may be used as a form for winding a good low loss coil. Six pieces of adhesive tape are placed gummed side up, and the wire wound over the adhesive... Not only does the adhesive reinforce the coil by holding each individual wire, but losses through absorption are not as high as when using the usual cylinder wound coil.

The insulating value of the form, if there is to be a form, is very important; a cardboard form, unvarnished or untreated, is best. However, the trouble lies in keeping the cardboard dry. Phenolic substances (bakelite, etc.), create a greater loss than dry cardboard. But in the long run the phenolic substances are better, because of the likelihood of a cardboard form absorbing moisture from the air. There is a growing tendency toward the use of wooden forms for all kinds of coils. These are all right if they are perfectly dry. Newly cut wood should never be used for anything in radio.

There has recently appeared on the market a so-called pickle-bottle coil, so named because the coil seems to have been the result of using a pickle-bottle as a form. Electrically, it is little better than the standard solenoid coil, and is superior thereto only because of the fact that it discards the form and is practically air-wound. Fig. 2 illustrates how the pickle-bottle coil is wound and its appearance upon completion.

The total distributed capacity of a coil of any type of winding is the sum of the capacities of the condenser effect of all the turns. Thus, with the distributed capacity kept low, the variable condenser to be used across the coil may have lower maximum value than otherwise, because the inductance of the coil is greater.

It is good practice when winding two coils on one form, to wind the two wires at once. For instance, we have a primary and secondary coil to be wound on the same form. For broadcast wave-lengths there are approximately eight turns on the primary and 50 on the secondary shunted by a .0005 mfd. variable condenser. Wind five turns of the primary first, then begin the secondary, winding both wires together side by side, so that the wire will be alternately primary and secondary for the duration of the three turns.

To reduce the resistance of any coil, keep all metal objects as far away as possible. Shielding the panel of a set should always be a last resort, because of the likelihood of increasing the effective resistance of all coils in the circuit. Metal placed within the field of a tuning inductance, for instance, may increase the resistance of the coil as much as .5 of an ohm.

In variable coils, such as the variometer or variable pan-cake coil, we must consider the variable inductive range between rotor and stator or fixed and variable coils. A well designed variometer will cover a wave-length range of 180 to 600 meters. Variometers are wound in cylindrical fashion, one coil rotating within the other, both coils being connected in series.

One manufacturer winds variometers in spider-web fashion, thus decreasing the capacity between coils, which is ordinarily quite high in this instrument. This type of winding in a variable coil makes tuning very sharp and reduces losses from absorption.

The toroidal winding is one of the most efficient of all coils. One may be constructed by the experimenter quite easily by following instructions: on a test tube approximately 10 inches long, wind 80 turns of No. 22 D.C.C. wire. Wind very tightly so that the entire winding may be slipped off the test tube without unrolling. When the wire has been removed from the test tube, it is bent into a doughnut shape. If a primary is desired, for use as a tuned radio frequency transformer, it may be wound on the test tube first, the secondary being wound over it, and slipping both off together.

The majority of the average coil losses may be kept very low, by keeping the field of the coil concentrated. Eliminate all forms whenever possible; keep the distributed capacity low by the proper form of winding; keep all metallic objects out of the field of the coil; use a large size wire, and for wave-lengths of 200 to 600 meters cylindrical coil forms should have a diameter of approximately 3½ inches. Following these rules with average mechanical workmanship will result in highly efficient inductances.

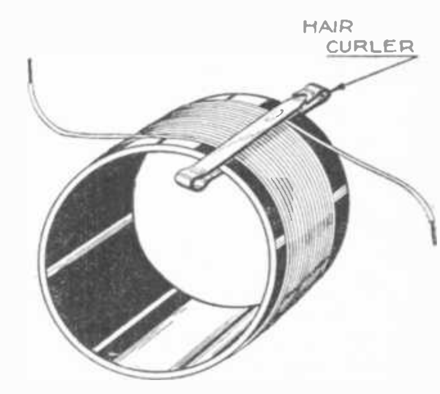
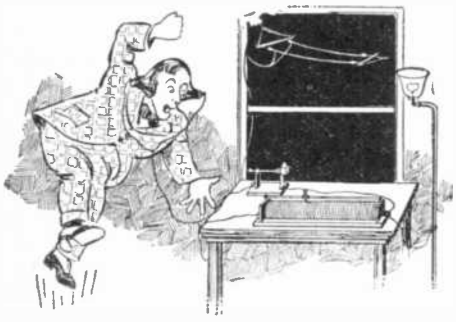


Fig. 3. Indicating a cylindrical form for winding solenoid coil. A hair curler, as shown in the illustration, may be used to fasten the wire temporarily so that it will not unroll.

When Radio Was Young.

By Sparks, The 2nd

WITH the varied stocks of radio stores at his pleasure, the present day radio amateur scarcely realizes the difficulties that beset the pre-war experimenter. Manufactured apparatus was expensive in those days and as the father of the young man rarely took much stock in his ambitious offspring's mania, the budding genius employed all his ingenuity (and most of them had a good deal) in devising ways and means.



"All I heard on this marvel of my inventive genius was a 60-cycle electric light hum. That served to bolster up my spirits, though."

A few of my personal experiences in this line may remind some of the old-timers of their own early troubles, back in the days when an aerial on the housetop branded one either a "wiz" or a lunatic. "Them were the days of real sport," though!

My earliest recollection of scientific endeavor is when, at the tender age of seven, I tried to translate a Wentworth and Hills' Textbook of Physics into comprehensible English. I didn't get far, I'll admit, and whenever I applied to papa, his long-winded explanation only confused me the more. The book had its two pages of Wireless Telegraphy and the apparatus described was a Hertz oscillator and a filings coherer receiver. I immediately decided to build one. I had a spark coil and an old bell for a tapper. I made a strap key and then cast about for coherer materials and some brass balls for a gap. They weren't forthcoming, however, so the set went to the discard, followed by many regrets. Of course, I had no intention at the time of not sticking to the specifications as given.

About that time I made a telegraph set of strap iron, stove bolts and five feet of wire. Say I wasn't tickled when it actually worked! I forthwith obtained an automobile axle key, made of quarter-inch hard steel, for the hammer of a more elaborate sounder. When I tried to drill a hole in it, I changed my mind.

I once made a "Tesla" coil having an eight-inch secondary wound with spaced No. 40 bare wire, and a four-turn primary. I expectantly connected it to a dry cell and was certainly disappointed when nothing happened but a shorted dry cell.

At the age of eleven I delved into the deep mysteries of spark transmission. I made a set which consisted of a strap key, stove bolt gap and a spark coil. I next erected a wonderful two-wire aerial, forty feet long, using covered No. 14 wire (I was lucky to have that). This set might have worked if I had had the juice to run it. After considerable discouraging experimentation with wet cells, I put my master mind at work on a receiving set.

The detector comprised two pieces of wire, two wood screws, a wood base and a hunk of coal, one wire being coiled up to hold the coal. I had heard somewhere that coal would work. I wish to state positively that mine didn't! As a tuner is simply a device to vary inductance, I stretched a two-foot brass spring on a board and made the contact by sticking a wire between the coils. The phones were a pair of 75-ohm Sampson's, borrowed from a wall telephone set, and connected by a spring brass headband. All I heard on this marvel of my inventive genius was a 60-cycle electric light hum. That served to bolster up my spirits, though.

My next was nearly a success. The detector was quite practical and the tuner certainly looked so (from a distance). I used to show it out of the attic window to admiring friends. I wouldn't risk a closer examination. It was a loose coupler of sorts and the tubes were wound with about fifty turns each, spaced nearly an eighth of an inch in order to cover the tubes. When I came to fasten the secondary leads to the copper rivet switch points, I was flabbergasted. Soldering was beyond me so I glued them on! I often used brass shoe nails for switch points and both glue and water glass took the place of the desired shellac.

Well, I hooked up the set and listened for the Arlington time signals one noon time. I knew I couldn't tune that high so I connected in a variometer seven inches in diameter and wound with about two hundred turns of No. 40 wire. In common with most of my kind, I have a vivid and rather flexible imagination. By stretching both properties to their greatest lengths, I heard the time sigs while scratching the galena with the cat-whisker. You see, I knew just what to listen for. I found that by moistening the crystal the "signals" were much louder. I intended to patent that idea. The incident always makes me think of "Ham Jones, scientist" and his famous unblowable fuse. I'll say one thing for those sigs, though, I could get them any time, and I never was able to decode them. Wonder what they meant?

The purchase of my galena might serve as a good illustration (if we need any, which I doubt) of how times have changed. I entered a large and well-known electrical supply store, which now supports a big radio department, and asked the clerk for a piece of galena. It went over his head so he called another clerk who dug up a small wooden pill box after a little search. It contained five hunks; I got three of them for eight cents!

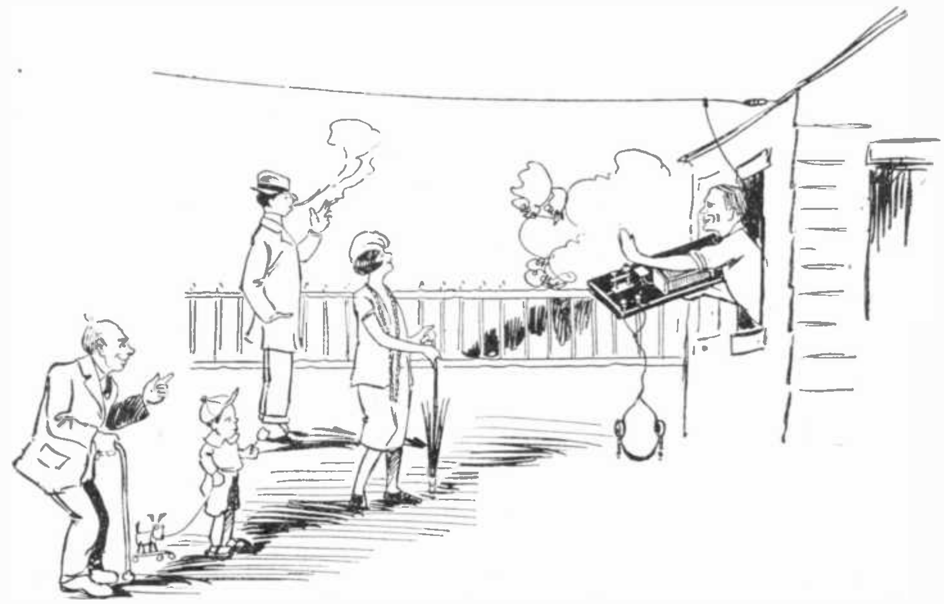
My chum, George, who lived about a block away was also interested so we began to experiment together. I would send messages to him, and then, as it was a one-way affair, beat it down to the telephone to talk it over. We rose considerably, in our own estimations, if in no one else's, when communication was actually established. I used an electric gas lighter as an independent vibrator and you can imagine the sweet tone obtained!

Those experiments marked a new era for us. From then on we began to get results. My older brother took the good old "E. E." for several years and you can bet that it filled one of kid brother's long-felt wants. Long live the EXPERIMENTER! May the new one inspire others as the old one did me.

"The first set that ever gave worthy results was a combination tube and crystal non-regenerative, using one of the old two filament audiotrons. I wish I had that tube now."

A surprising number of "radio experts" have sprung up in the past few years. If you don't believe me, just go into any radio store, preferably the "Five-and-Ten" and listen to the sage remarks passed by various authoritative customers. They certainly solve some deep theories very satisfactorily to themselves.

Well, O. M., the good old days are gone, I guess, but let's hope they'll repeat themselves! History always does, you know!



"I used to show it out of the attic window to admiring friends. I wouldn't risk a closer examination.

"How many of us have had similar experiences? And how our mothers were regarded with great envy by an awed populace, when their sons would dangle from dizzy heights to put up an aerial or other fool thing!"

The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

CALIBRATING THE WAVEMETER

IN radio data sheets 14-10 and 14-11, an elementary explanation of the principles involved and the construction of a simple wavemeter were given. After the wavemeter has been completed, the next thing that is required, to make the meter of value to the experimenter, is to calibrate it. As explained in data sheet 10-8, if a parallel circuit, consisting of a condenser and coil, be connected in series with a source of high frequency energy, no energy will be allowed to flow through the series circuit, when the parallel circuit is tuned to the proper frequency.

This principle is utilized in the wave-trap, or filter, and is the simplest one to use in calibrating a wavemeter. The wavemeter is connected in series with the antenna circuit of a radio receiver. If, when signals are being received, the condenser of the wavemeter be slowly rotated, a point will be found at which the signals either completely or nearly disappear. This is the adjustment of the wavemeter at which the resonant frequency of the wavemeter is the same as that of the incoming signal. The experimenter, may then put down in his notebook the dial setting of the wavemeter condenser and the wave-length of the incoming signals, which he may obtain from any up-to-date list of stations or from a call-book.

This should be done for as many stations as it is possible to receive. When the tests have been completed, the wave-lengths and condenser settings should be plotted on cross-section paper, as shown in the illustration, and a curve drawn through the points. The points should be located as accurately as possible and this requires that the wavemeter have as little resistance (or losses) as possible.

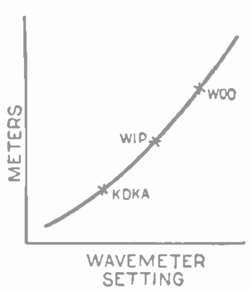


FIG. 5

14-12

The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

UNITED STATES CALL LETTER ASSIGNMENTS

THE service regulations of the International Radiotelegraphic Conventions provide that the call-letters of stations in the international system must each be formed of a group of three letters which shall be distinguishable from each other. The London International Radiotelegraphic Conference made a partial allotment of call letters, among nations which signed the convention, and the International Bureau at Berne, with the consent of such nations, has modified and added to this assignment of call letters.

The call-letters assigned to the United States are the following: all three- and four-letter combinations beginning with the letter N (NAA-NZZ), and all those beginning with the letter W (WAA-WZZ), and all those beginning with the letter K, KDA to KZZ inclusive. The international call-letters assigned to the United States are reserved for Government stations and stations open to public and limited commercial service.

All combinations beginning with the letter N are reserved for government stations, and, in addition, the combinations from WUA to WVZ and from WXA to WZZ are reserved for stations of the United States Army.

During the war the combinations of three letters beginning with W, K and N were exhausted, and it was necessary to assign combinations of four letters beginning with K, W and N. These assignments are as follows:

KDA-KZZ	Commercial stations
NAA-NZZ	Navy stations.
WAA-WTZ	Commercial stations.
WUA-WVZ	Army stations.
WWA-WWZ	Commercial stations.
WXA-WZZ	Army stations.

These combinations with three letters are used largely for ships and coast stations working with ships, although some broadcasting stations have been given three letter calls where these are not required for ships or coast stations working with ships. The assignment of call letters to amateur radio stations, which are scattered throughout the United States in great numbers, was a problem which was separate from the allotments made by the Berne Convention, which took into account only the international radio relations. On account of the liability of interference from amateurs with the regular government and commercial traffic it was necessary to regulate the transmission of amateurs and impose limits upon them with regard to power, frequency, and call-letters.

15-20

The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

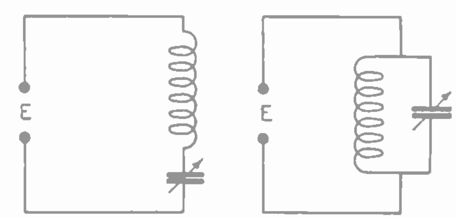
SERIES AND PARALLEL RESONANCE

IN Radio Data Sheet 10-6 the difference between the series and parallel connections in tuned circuits was explained; in this sheet we will discuss the action of these two circuits when alternating voltages of either high or low frequency are impressed upon them. For convenience the two circuits are reproduced here.

Every combination of inductance, L, and capacity, C, in any circuit has associated with it a definite frequency as explained in 1-30. This is the frequency at which the greatest amount of current will flow in the circuit and is termed the *resonant* frequency. When the series circuit consisting of L and C in series with the emf. is in resonance, the greatest current will flow through the circuit. Since the source of emf., E, is in series with L and C, the current must also flow through E.

In the case of the parallel circuit, however, when L_1 and C are so adjusted that their resonant frequency is the same as that of E, the source of emf., the greatest current will flow through L and C as before, but this time it will not have to pass through E, since E is not in series with L and C. A large circulating current will therefore flow through L and C, but very little, if any, current will flow through the external circuit where E is located.

In the case of series resonance, therefore, the greatest current will flow from the source of EMF., whereas in the case of parallel resonance the least amount of current will flow.



-SERIES CIRCUIT- -PARALLEL CIRCUIT-

10-8

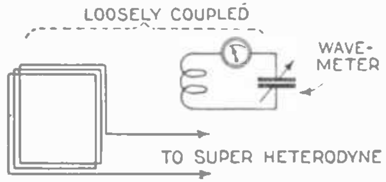
The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

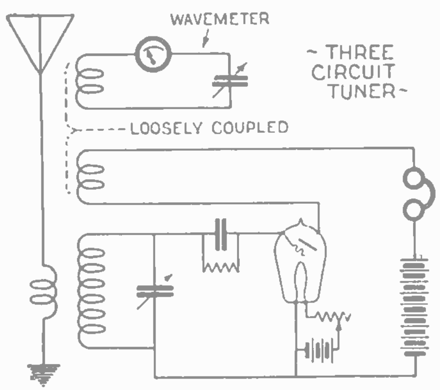
CALIBRATING THE WAVEMETER [Continued]

In radio data sheet 14-12 a simple process was given for calibrating the wavemeter, but this is probably, in most cases, not a very accurate method. A more accurate way is to receive the signals on a regenerative tuner, such as a three-circuit tuner, having the tickler coil adjusted as near to the point of oscillation as possible.

When the wavemeter is brought near to the tuning coil of the receiver and adjusted to resonance by turning the wavemeter condenser dial, a howling will be heard in the phones, which indicates that the wavemeter is tuned to the same wave-length or frequency as the receiver and the incoming waves



Another way is to couple the wavemeter loosely with the loop of a Super-Heterodyne receiver. It will in general be found that the Super radiates, so that considerable deflection can be obtained in the wavemeter thermogalvanometer, when the wavemeter is tuned to the incoming wave.



14-13

The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

CALL LETTER ASSIGNMENTS [Continued]

Not falling in the category outlined in 15-20, the amateurs were assigned call-letters beginning with numbers, these numbers being in accordance with numbered divisions of the United States. There are nine districts, as listed below, the number preceding the call-letters indicating the district in which the station is located. In the following list are given the states in each district:

1. Headquarters, Boston, Mass. (radio inspector, customhouse): Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut.

2. Headquarters, New York, N. Y. (radio inspector, customhouse): New York (County of New York, Staten Island, Long Island, and counties on the Hudson River to and including Schenectady, Albany, and Rensselaer) and Northern New Jersey.

3. Headquarters, Baltimore, Md. (radio inspector, customhouse): New Jersey (all counties not included in second district), Pennsylvania (all counties south of the Blue Mountains, and Franklin County), Delaware, Maryland, Virginia, District of Columbia.

4. Headquarters, Savannah, Ga. (the work of this district is being performed by the radio inspector of the third district, customhouse, Baltimore, Md.): North Carolina, South Carolina, Georgia, Florida, Porto Rico.

5. Headquarters, New Orleans, La. (radio inspector, customhouse): Alabama, Mississippi, Louisiana, Texas, Tennessee, Arkansas, Oklahoma, New Mexico.

6. Headquarters, San Francisco, Calif. (radio inspector, customhouse): California, Hawaii, Nevada, Utah, Arizona.

7. Headquarters, Seattle, Wash. (radio inspector, 2301 L. C. Smith Building): Oregon, Washington, Alaska, Idaho, Montana, Wyoming.

8. Headquarters, Detroit, Mich. (radio inspector, Federal Building): New York (all counties not included in second district), Pennsylvania (all counties not included in third district), West Virginia, Ohio, Michigan (lower peninsula).

9. Headquarters, Chicago, Ill. (radio inspector, Federal Building): Indiana, Illinois, Wisconsin, Michigan (upper peninsula), Minnesota, Kentucky, Missouri, Kansas, Colorado, Iowa, Nebraska, South Dakota, North Dakota.

15-21

The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

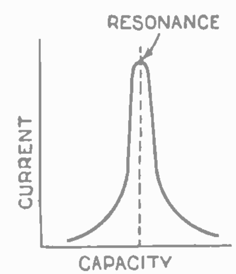
SERIES AND PARALLEL RESONANCE [Continued]

How the amount of current through the two circuits shown in data sheets varies with the adjustment of the condenser can be visualized by the figures shown here. Fig. 1 is for the case of series resonance, and represents an ordinary tuning coil secondary connected to a variable condenser.

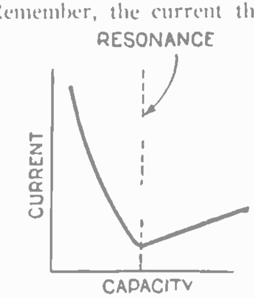
We are supposed to be receiving signals which have a certain frequency. When the condenser is set at zero, no current flows in the circuit. As the capacity is gradually increased (and we move toward the right on the figure), the current increases, at first slowly and then more rapidly, until a maximum value is obtained. This is the resonant point.

As the condenser dial is turned still further, the current decreases, at first rapidly, and then more slowly. At all points other than the resonance point the current is very small. This is what happens when we tune in to a station. As we turn the condenser dial we begin to hear the signals when the current has become great enough, and as we continue to turn it we find the point at which the signal is loudest. This is the point of resonance.

The opposite state of affairs holds with regard to parallel circuits. The current is relatively large when the condenser is at zero, but as the condenser is turned it drops off very rapidly to a minimum point (the point of resonance) and then begins to rise again. Remember, the current that we



SERIES RESONANCE



PARALLEL RESONANCE

are talking about is not the circulatory current through L and C, but the current in the external part of the circuit. (See 10-8.)

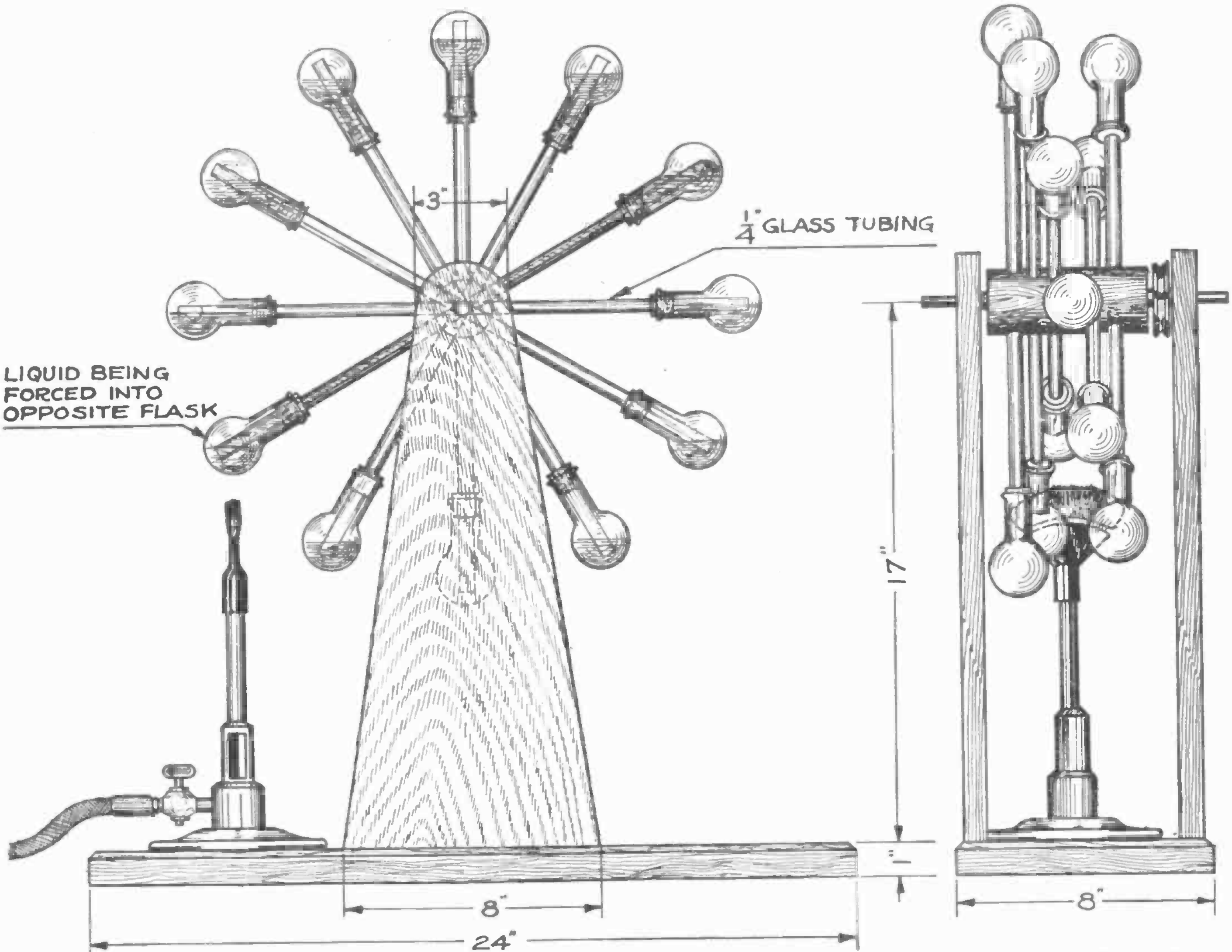
10-9

CUT ALONG PERFORATED LINES

EXPERIMENTAL CHEMISTRY

How To Make A Chemical Flask Motor

By Earle R. Caley, B. Sc.



This ingenious motor operates by the fluid being forced over to one side of the axle by the heat of a Bunsen burner. It is a chemist's motor, being made up of chemical supplies. It is well to have a fan tip for the burner if the tubes are arranged as shown.

A NOVEL and unusual heat motor that really works and is easily made from some flasks, a few pieces of glass tubing and some wood, is shown in the accompanying illustrations. Small chemical flasks are mounted up on the ends of some straight glass tubes which are fixed to a revolving shaft. The ends of the glass tubes reach nearly to the bottom of the flasks. The flasks contain some volatile liquid such as ordinary denatured alcohol, ether or acetone. When heat is applied to the flasks on one side by a Bunsen burner, the pressure of the liquid vapor in the heated flask forces the liquid over to the flasks on the opposite side, overbalancing the system and causing the whole to rotate. This action is fairly rapid. The details for the successful construction of this motor are given below.

The base is a piece of one-inch wood twenty-four inches long and eight inches in width. This may be given a beveled edge for the sake of appearance. The two side supports are fastened with wood screws coming up from the underside of the base; they are seventeen inches in height and are spaced six inches apart. They taper from a width of eight inches at the bottom to three inches at the top. For rigidity, a short piece of wood should be placed between them at about four inches above the base and the supports are fastened to this by screws. Fifteen inches from the bottom of the side pieces and in the exact center are drilled two one-quarter-inch holes which are to receive two tubular bearings on the axial line, upon which the whole device revolves. The next step is the assembling of the revolving part.

The following pieces of chemical apparatus are required: Six or more round-bottom flasks of two ounces capacity or about 60 cubic centimeters; several pieces of one-quarter inch diameter glass tubing; and sound perforated corks which will fit firmly in the necks of the flasks. These supplies are obtained from a dealer in experimenter's materials. The glass tubing is cut to lengths of fifteen inches and three to six pieces are required. They may be cut to the length by nicking with a file and bending the tube sharply while holding the thumbs on each side of the scratch and pulling lengthwise. These pieces of glass tubing are now to be fitted in holes drilled transversely through a cylindrical piece of wood, which is five inches in length and has a diameter of two inches. Of course, the best way to obtain this is to turn it up in a lathe, but a section sawn out of a length of curtain pole will serve just as satisfactorily. Near to one end a groove should be made which can serve as a pulley from which some light mechanical device can be operated.

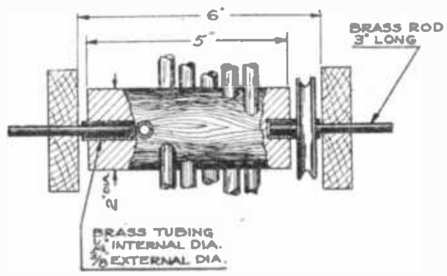
The holes to receive the glass tubes are drilled at proper intervals and are of a slightly larger size than that of the glass tubes. They must pass directly through the axis of the cylindrical piece. This latter is an important point, since if some of the holes are only slightly off center, they will cause a considerable displacement of the flasks on the ends of the tubes and interfere seriously with the proper balance of the revolving part. Two holes are also drilled in the exact center of the ends of this wooden cylinder to act as holders for the bearings. These holes are three-eighths of an inch in diameter and three-quarters of an inch deep.

Two short pieces of brass tubing having an external diameter of three-eighths inch and an internal diameter of one-quarter inch are firmly inserted in these holes to serve as bearings for the pivots placed in the supports, as described below. The three pieces of glass tubing should now be permanently fixed in the wooden cylinder by means of thick shellac. Care should be taken that an equal length of glass tubing projects on either side. After the shellac has dried thoroughly, the cylinder now holding the glass tubes may be permanently mounted in place.

Two short pieces of brass rod three inches in length and one-quarter inch in diameter are employed as pivots. The method of mounting is shown in detail. At one end, if necessary, they should be carefully filed down until they fit smoothly and turn freely in the inside of the tubes in the wooden piece. After this they should be driven into the side supports and into the end bearings of the wooden cylinder. The cylinder is now fixed in place and should revolve with perfect ease and freedom with but little side play.

The next step in the construction of the motor is the filling and attaching of the glass flasks to the ends of the glass tubes. It is essential that the corks used be free from holes and cracks liable to cause leakage. The use of rubber stoppers is not advisable on account of the solvent action on the rubber of the hot liquids used. Holes should be made in these corks of such a size that they will fit tightly into the glass tubes. This is best done by using a regular cork borer which should be sharp. A good manipulator can make the holes with a rat-tail file.

The method of attaching these flasks is as follows: A flask is half filled with the liquid used, a cork smeared with glue is then pushed over the end of a glass tube when it is at the bottom position, and the cork and the flask is pushed on until the glass tube is one-quarter of an inch from its bottom. The cork must be firmly pressed home. As an additional protection against the expulsion of the cork under the pressure of the heated vapor, the cork should be neatly wired on by making a circle of copper wire under the flange of the neck of the flask and attaching wires to this which pass over the top of the cork. Another flask is attached in the same way at the end of the next glass tube, also when it is in the bottom position, and so on all around until the six flasks have been fastened on. The motor is now complete except for giving the wooden parts several coats of orange shellac or varnish to improve the appearance.



The shaft and central mounting of the chemical motor are shown above partly in section. It is essential to avoid friction and have good bearings for the shaft shown extending to the right and left.

To operate this motor, it is only necessary to place an ordinary Bunsen burner in the position shown. The wheel of flasks almost immediately starts in motion and continues as heat is applied. The speed of the motor can be regulated by raising or lowering the gas flame. Various liquids can be experimented with for the filling of the bulbs, carbon disulphide, alcohol, acetone, benzene, carbon tetrachloride, etc. Of course, proper precautions should be used in heating the more combustible ones. An additional effect is obtained if a dye of some sort is dissolved in the liquid before filling into the flasks. This is an exceedingly interesting motor to watch in operation, with the constant squirting of the liquid into the upper flasks in rapid succession. The balancing can be effected by pushing the flasks in or pulling them out a little, and by the quantity of liquid in each.

Decompositions of a Hydrocarbon Gas

By Donald E. Learned

A FLASK, or a pear-shaped lamp bulb with base cut off, is fitted with a two-hole rubber stopper. Through the stopper are pushed two tubes, one, I, having a jet, J, on

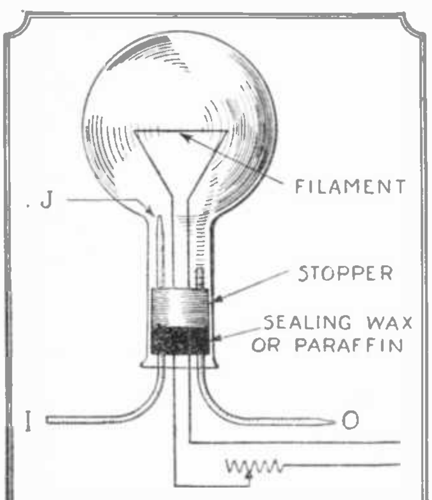


FIG. 1

Decomposing a hydrocarbon gas by an ignited filament. Chemical decomposition is the result, with deposition of carbon. The hydrocarbon gas enters and the gas which leaves while not pure hydrogen is considerably poorer in carbon.

its inner end, and the other, O, having a jet at its outer end. Two wires are pushed through the stopper, as shown in Fig. 3, and a filament of fine wire fastened across the inner ends, so that when the stopper is pushed into the flask the apparatus will appear as in Fig. 1.

Connect tube I to the laboratory gas-cock by means of a rubber hose. The outlet tube O may ventilate to the open air by means of a hose, or the whole outfit may be placed under the hood. Connect the filament leads to a battery or step-down transformer through a rheostat, but do not turn on any current. Now turn on the gas and let run a few seconds until the air is all out of the flask. Current may now be turned on very slowly.

The writer obtained the following results using natural gas and a tungsten filament. At low red heat no results were apparent. At bright red heat slight decomposition of the gas. At low yellow heat dense white fumes formed and liquid hydrocarbons similar to kerosense, condensed in flask. At medium yellow heat—fumes denser and darker. Dark condensation in flask. Odor of benzene products at jet O. At bright yellow heat, fumes almost brown, brown condensation in flask, odor of crude phenol. A piece of paper held against jet O was stained dark brown, almost black. At white heat, fumes very dense, soot deposited. Leads to filament burnt off. Filament had a thick white coating at end of experiment, which no doubt caused the increased current-carrying capacity.

The above experiment may be performed with the addition of a condenser attached to the outlet jet and the resulting liquids saved for analysis. Although the flask is shown inverted it may be placed in an upright position if the resulting materials are not to be collected. As shown, with a cool wet cloth spread atop the flask, a fairly efficient condenser is formed by the flask itself.

In another experiment a similar apparatus is employed but the filament is omitted. The wires are preferably made sufficiently heavy so that the space between the inner ends can be adjusted by swinging the outer ends. These wires are connected to a spark coil or high tension transformer so that an arc may be formed between them. The gas is connected as before and sufficient amount run through to assure a non-explosive mixture before the spark is turned on. As soon as all the oxygen remaining in the flask is consumed, a tree of carbon will be formed on the end of each electrode, building up and carrying the arc up as they grow. These

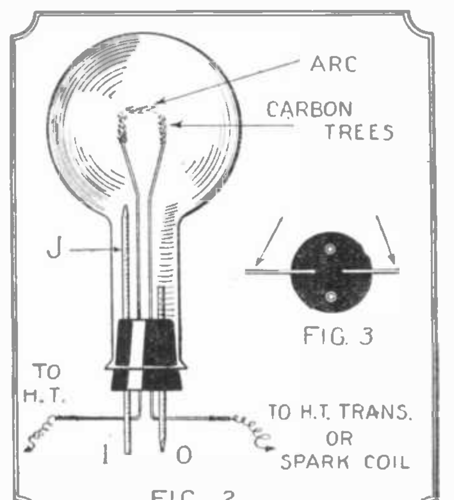


FIG. 2

Using a spark or arc discharge for effecting the decomposition as described. A spark coil or high potential transformer can be used. A sort of bridge of carbon from electrode to electrode is produced.

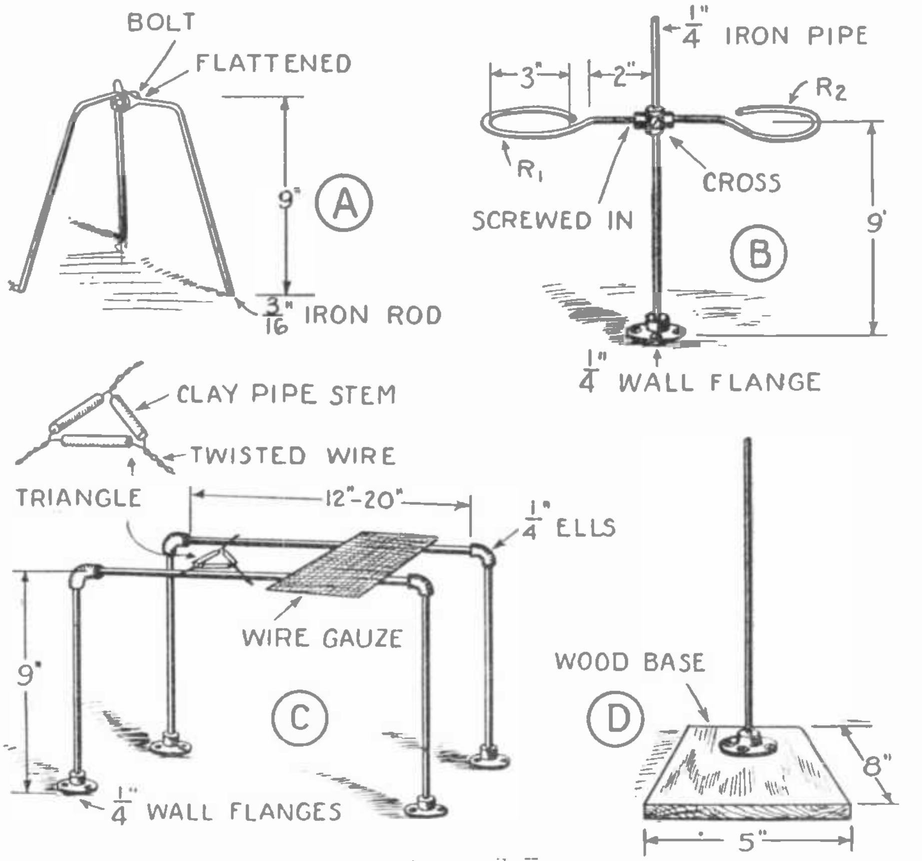
trees seem to be made of rather hard carbon, almost crystalline in appearance. Hydrogen is set free from the gas.

The purpose of the inlet jet is to distribute the gas thoroughly in the flask. The outlet jet keeps the contents at a pressure slightly above atmospheric and prevents the entrance of air. Take all precautions to prevent explosion either in the flask or from escaping gas.

This experiment is in the line of what is technically called "cracking" of petroleum products; it is used on a vast commercial scale.

Laboratory Supports from Pipe Fittings

By Raymond B. Wailes



Various chemical apparatus made out of pipe fittings and pipe are shown above. Especially the use of the wall flange is to be noted, as this gives an exceedingly firm support and also makes an admirable foot for such pieces as do not require to be screwed down. The triangle is made of twisted wire and pieces of the stem of a clay pipe are strung upon it as shown, to avoid contact of a crucible or other vessel placed on it with the iron. They also prevent the oxidation of the wire.

THE piece of laboratory apparatus which is universal is the laboratory support, also called retort stand or ring stand. No experimenter's laboratory is complete without half a dozen of them. Filtrations, evaporations, distillations, etc., can all be performed on a laboratory support with the necessary adjuncts such as burette clamps, rings, etc.

Many experimenters will find meat in this little article, to be sure. Have you ever thought of having a small table devoted entirely to the heating of solutions, evaporations, digestions, incinerations, fusions, etc.? The little stand made as shown in C will serve admirably for this purpose. It should be fastened rigidly to the bench built especially for this kind of work.

This stand is made from ¼" iron gas pipe. A height of 9" will be found right for many purposes, or a height of from 12" to 20". Quarter inch "ell" pieces will serve to make the bends, and wall flanges the leg supports. The wall flanges come drilled with four countersunk holes and these enable one to fasten the stand to the bench. Bunsen burners placed beneath the whole will heat any solutions placed in beakers on the wire gauzes laid over the top bars. Pipe stem or michrome triangles will serve to support crucibles for incinerations, fusions, etc.

In A is shown how a tripod which can be moved anywhere on the bench is made. It is composed of 3/16ths iron round rod, flattened to take the bolt which binds the pieces together. The 9" height will again be found about right. This type of tripod cannot be used to hold a funnel for filtering, however. It makes a good support for a wire gauze or plated thin iron upon which solutions are placed to be heated.

Fig. B shows a double duty support made from two 9" lengths of ¼" iron pipe, a ¼" cross-piece, a ¼" wall flange and two rods threaded to fit into the arms of the cross, these rods being bent into the shape of a circle to form the familar rings upon which wire gauze or sheet iron is placed to heat beakers, and into these rings funnels are thrust for filtrations, etc. The whole can be screwed to the laboratory table top or to a board about ⅞" thick. A coat of aluminum paint will make the completed apparatus look very commercial. Of course the old familiar black stovepipe enamel can be applied just as well.

The simplest pipe-fitting laboratory support is indicated in Fig. D. An 18" length of ¼" iron pipe is threaded at one end and screwed into a wall flange which is in turn affixed to a 5" by 8" piece of ½" or ⅞" dressed board for a base.

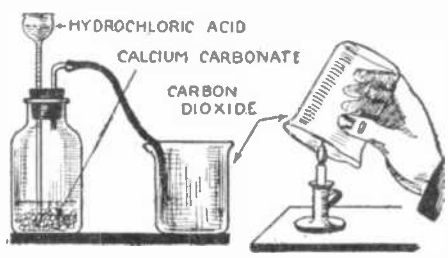
Fire Extinguishing

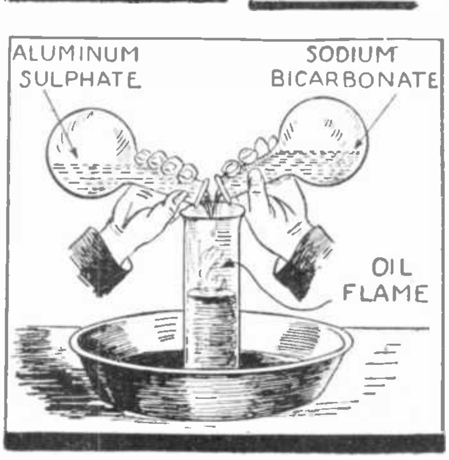
By Simon Liebowitz

CARBON dioxide (CO_2) has the property of extinguishing a flame. This principle is employed in most fire extinguishers. To demonstrate this a curious and amusing experiment may be performed.

To generate carbon dioxide place a number of crystals of limestone, calcium carbonate, ($CaCO_3$) in a bottle with a two-hole stopper. In one hole insert a thistle tube and in the other a glass tube to which is connected a length of rubber hose. Pour a quantity of hydrochloric acid (HCl) into the thistle tube and immediately a strong chemical action will take place in the generating bottle. Now lead the hose into an empty glass jar. The gas being heavier than air, it will not be necessary to use a pneumatic trough for its collection. After a quantity of the carbon dioxide has been obtained, invert the jar over a burning candle. Immediately the flame will be extinguished. This appears rather strange as the carbon dioxide is a colorless gas. (Refer to diagrams 1 and 2.)

When oil burns, however, we have an entirely different situation. If an oil flame is played upon with a stream of water, the oil being lighter, it will float on top of the water and there will be no effect upon the flame. To overcome an oil fire two liquids are played upon it simultaneously, aluminum sulphate ($Al_2(SO_4)_3$) and sodium bicarbonate ($NaHCO_3$), the first containing a little blue in solution.





To demonstrate this a long glass beaker partly filled with burning oil or water is placed in a pan. Both solutions are poured in together. Immediately a thick, white foamy froth rises to the top of the beaker and overflows it. A multitude of small bubbles of carbon dioxide are formed which are entirely effective in extinguishing the oil fire. (Refer to diagram 3.)

The upper cut shows the collection of carbon dioxide gas in a beaker or similar vessel and the extinguishing of a candle by pouring the gas over it. Below is shown the foam system of extinguishing burning oil. A certain amount of glue is dissolved in water, so that as carbon dioxide gas rises in bubbles, it is retained long enough to do good work.

The following is a formula for making the two aforementioned liquids:

Solution I

Water (H_2O)	100 parts
Aluminum sulphate ($Al_2(SO_4)_3$)	14 parts
Glue	3 parts

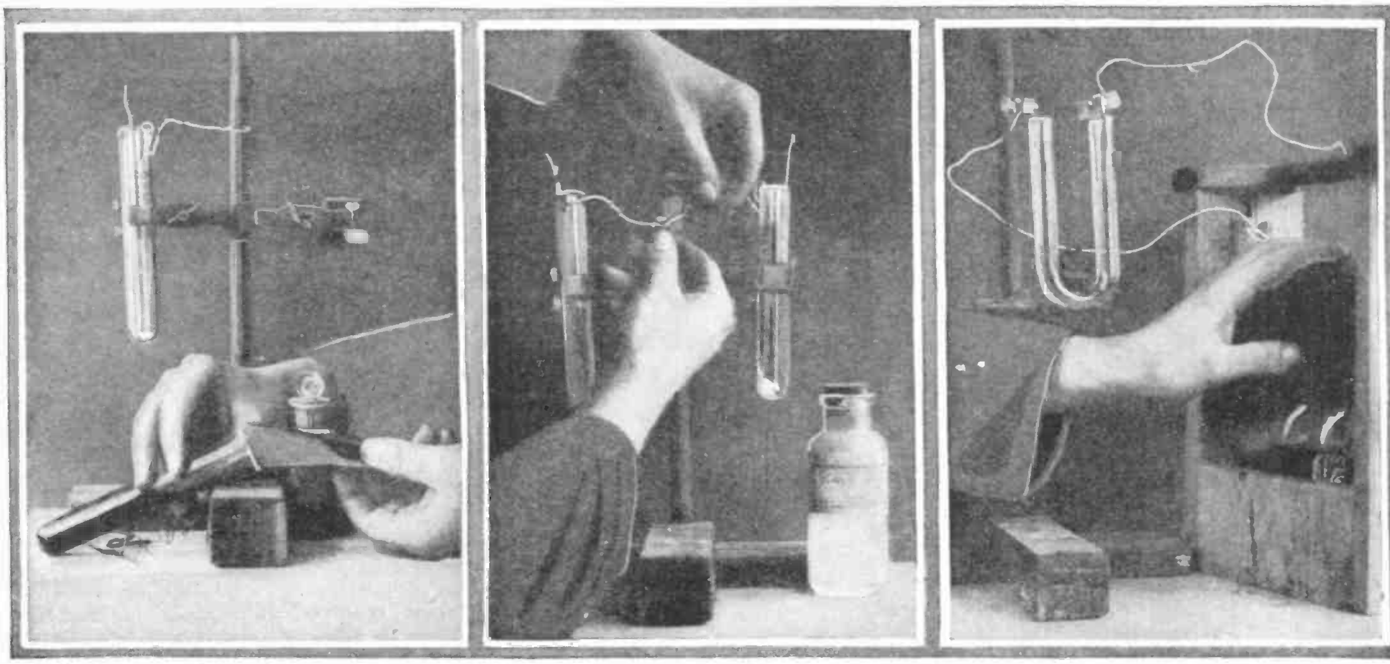
Solution II

Water (H_2O)	100 parts
Sodium bicarbonate ($NaHCO_3$)	9.25 parts

The glue in solution I is used in order to keep the carbon dioxide bubbles from breaking too readily.

Migration of Ions

By Dr. E. Bade



Make a concentration cell to generate electricity by pouring concentrated acid into a tube and cover with water containing a drop or so of the acid. Insert the copper electrodes and connect to another cell also having copper electrodes but placed in a solution of copper sulphate. Quite a deposit of copper will be formed on one of these electrodes in a few hours proving that electricity was developed by the concentration cell. In a U-tube place a solution of table salt in water containing a little blue litmus. Connect to a source of direct current.

THE conductivity of a solution depends on the fact that when two oppositely charged poles are placed in solution, the positive charge of the current attracts all the negatively charged particles or ions within its field and repels all positive particles, the ions themselves being formed by the dissociation of the molecules in solution. They are not identical with the atoms, but differ mainly in having a charge of electricity. The movement of the electrically charged particles in opposite directions through a solution produces an electric current and such a current has the properties of a current through a wire. When the ions touch an electrode, they are discharged, and with the discharge the ions are changed to atoms.

This change from ion to atom and from atom to ion may either produce or use up a quantity of energy. That is, energy may be derived from this change, or energy must be put in this system to make the reaction take place. The latter case is seen when electroplating is accomplished, for then a given quantity of current will decompose equivalent quantities of electrolytes and deposit equivalent quantities of metal, and energy is absorbed in the process.

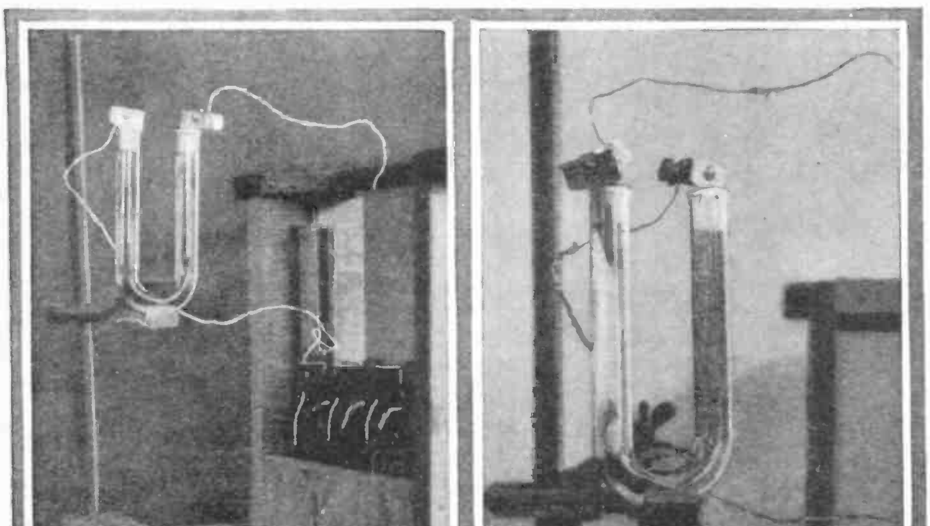
An electric current may be produced by using nothing more than two copper electrodes, a vessel, hydrochloric acid and water. The energy produced may be small, which is natural, so the method used for its detection and measurement must be adapted to the nature of the substance under consideration. Here the so-called concentration cells are used where unequal concentrations of given ions produce the current.

A galvanometer or an ammeter capable of registering minute currents is used to determine or measure such diffusion currents. For hydrochloric acid, no large quantities are required. In a test tube about ¾-inch diameter place a rubber-covered wire having about 2 inches of the copper wire exposed and wrapped around the rubber insulation. Place the tube in some holder to keep it firm. Introduce concentrated hydrochloric acid, filling it about one-quarter full. Then carefully add an equal quantity of water which has been acidulated with one drop of hydrochloric acid. The two solutions must not mix. Touching the top of this very weak acid solution is another copper electrode made from wire. Connect the two ends of the wire to the meter and a deflection of the needle will take place showing that a current of electricity is being generated. This current will flow for many hours, gradually decreasing in intensity as the concentration of the two liquids is being equalized.

Such currents, produced by the unequal diffusibility of ions, not only depend upon the concentration of the electrolytes brought in contact with each other, but also upon the relative degree of ionization of the chemical used. Non-ionizable substances such as sugar, do not produce such currents, but acids, bases and salts do.

The direction of current flow will be found, when connected to a delicate galvanometer, to be from the dilute solution through the conductor and back to the minus electrode in the concentrated solution. The upper electrode is charged positively by the rapidly moving hydrogen ions coming from the concentrated solution. The visual effect of such currents can also be demonstrated by connecting the wires of the concentration cell to a test tube containing copper sulphate. Quite a deposit of metallic copper will be formed during the day, the copper being plated upon that electrode connected to the lower plate of the concentration cell.

It is the dissociated molecules or ions which are the real carriers of electricity in the passage of a current through an electrolyte and they therefore must not only have an equal number of negative and positive charges, but each kind of ion must move



In a short while the anode or positive connection to the battery will be surrounded by a red solution showing that this leg of the U tube has an acid reaction. When potassium permanganate is placed in such a U tube and a current is passed through, a migration of ions also takes place, the colored ions traveling to the positive electrode which leaves the other leg of the tube colorless.

Mosaic Gold

By Earle R. Caley, B. Sc.

MOSAIC gold is a pigment often used for artistic decorative effects where a peculiar, subdued effect of old gold is desired. This substance consists of beautiful golden scales and is really tin sulphide (stannic sulphide) in the crystalline form. The preparation of this substance from metallic tin forms an instructive and easily performed experiment for the chemical experimenter. Only common and readily procured chemicals are required to carry it out.

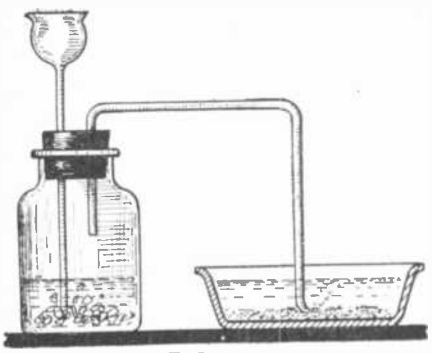


FIG. I

Passing hydrogen sulphide gas through a solution of tin chloride in order to precipitate the sulphide which is the basis for a sort of bronze powder called mosaic gold. It gives a dark brown dull precipitate, to be brightened by subsequent treatment.

The metallic tin used should be the so-called "mossy tin" formed by pouring molten tin into water. It is in this form that pure tin is usually sold by chemical dealers. Twenty-five grams of the metal are placed in a beaker along with 150 c.c. of concentrated hydrochloric acid. A watch glass is placed on the top of the beaker to prevent undue loss of acid, while the tin is going into solution. The beaker is then placed over a Bunsen burner and the contents are heated to boiling and kept in ebullition until all of the metal dissolves, a process that will occupy several hours. As soon as solution is complete, the watch glass is removed, washed off with the wash bottle into the beaker, and the solution is evaporated until only a moist residue of tin chloride is left. Towards the end of the evaporation the heating should be cautious in order to prevent loss by spattering. The moist salt is then transferred to a good-sized enameled dish or pan and dissolved with 2,000 c.c. of boiling water.

Hydrogen sulphide gas is now passed through the solution in order to precipitate the tin in the form of stannous sulphide, the lower sulphide of the metal. This operation is illustrated in Fig. 1. The generator for the gas consists of a wide-mouthed bottle provided with a double-holed rubber stopper or good quality cork through which passes a thistle tube and a glass delivery tube as shown. Lumps of iron sulphide are placed in the bottle, the cork is replaced and dilute sulphuric acid is poured through the thistle tube. Evolution of the gas commences as soon as the acid is added and bubbles through the solution in the dish. A brownish-black precipitate of the tin sulphide appears in the solution at once. The gas is passed in until no more sulphide is formed. On account of the disagreeable odor of the hydrogen sulphide gas, the operation is best performed outdoors on a window sill, or under a chemical hood.

When no more tin sulphide is formed, the precipitate is allowed to settle and the clear liquid above it poured off carefully without disturbing the solid. The dish is then filled with water again, the precipitate allowed to settle and the solution poured off as before. After repeating this again, the solid will be thoroughly washed. The moist solid is then collected on a watch glass and placed in an oven heated to 100° Centigrade and left in the oven until dry.

The next step in the process is the conversion of the dull, dark brown stannous sulphide into the brilliant shining crystalline stannic sulphide. An apparatus for doing this is shown in Fig. 2. Twenty-five grams of the dry powder obtained above are thoroughly mixed with 15 grams of flowers of sulphur and 10 grams of pure ammonium chloride and placed in a large test tube which is loosely clamped in a slanting position as illustrated. The tube is then heated with a Bunsen burner having a wing-top attachment and adjusted so that it will burn with a smoky flame, the idea being to heat the entire mixture evenly and at a low temperature. While heating, the tube should be turned slowly. Dense white fumes of ammonium chloride will be evolved from the mixture. As soon as these fumes have ceased coming off, the tube is heated for five minutes with the usual Bunsen burner non-luminous flame. The tube is then allowed to cool down and will be found to contain a considerable quantity of beautiful golden yellow scales. This product is the so-called mosaic gold.

If a small quantity of metallic mercury can be obtained, the mosaic gold can also be made by a more direct procedure. Thirty grams of pure tin are melted in a crucible and 15 grams of the mercury thoroughly stirred into the melted metal. The amalgam thus formed is allowed to cool down, and when cold is placed in a mortar and reduced to a fine powder. This is readily done on account of the brittleness of the amalgam. The powdered metal so obtained is mixed with 15 grams of ammonium chloride and 20 grams of flowers of sulphur and placed in a small Florence flask. The flask thus charged is placed in a small iron dish filled with sand. The dish and its contents are then mounted over a Bunsen burner and are gradually heated until no more white fumes of ammonium chloride are evolved.

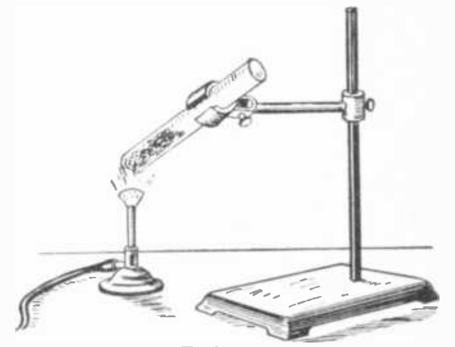


FIG. 2

Igniting the dull tinted precipitate of tin sulphide, having first mixed it with flowers of sulphur and ammonium chloride in the proportions given. The temperature is kept rather low and shortly after the fumes cease, the tube is allowed to cool, and will contain a quantity of beautiful golden yellow scales.

The heating is continued until a very low red heat is obtained. The flask is then removed from the sand bath and on cooling will be found to contain the characteristic beautiful scales of mosaic gold.

Migration of Ions

(Continued from preceding page)

through the solution with its own speed which depends upon the type of ion. The ions themselves cannot be seen, but the effect and rate of their speed can be made visible in various ways. Probably the best way of showing the effect is by means of an indicator such as litmus. Ordinary table salt, sodium chloride, is used as the salt and this is dissolved in water, a pinch of salt to one or two ounces of water being sufficient. To this is added enough litmus solution to produce a faint color when thoroughly mixed. If this solution is not at hand, three or four pieces of blue litmus paper are placed in the salt solution and left until the liquid has a slight blue tinge. Then the solution is poured into a U-tube until it is filled. In each leg insert a T-shaped electrode cut from thin sheet aluminum. Connect these electrodes to a source of direct current such as a plunge battery and let the current pass. After about five or ten minutes, the cathode or negative electrode will be surrounded by a blue solution, showing the presence of an alkali, while the limb of the U-tube in which the anode or positive connection to the battery has been made will be changed to red, showing an acid.

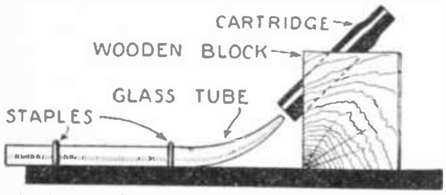
The metals are generally called electropositive elements because they show a great tendency to lose one electron, thus becoming positively charged particles. In this case the sodium loses an electron from those originally in the element, while chlorine, the other constituent of table salt, which is an electronegative element, has an opposite and great tendency for catching and holding on to an extra electron, thus becoming negatively charged. The negative charge on the cathode in the U-tube repels the chlorine ions and attracts the sodium ions, while the reverse is true of the anode or positive electrode. The result produced by this attracting and repelling force is a migration of ions, and the effect of this migration has been made visible by means of litmus, because the ions, when they touch an electrode, are discharged. This contact changes this particle both chemically and physically. The discharged sodium ion receiving an electron is converted into metallic sodium which reacts with the water forming sodium hydroxide; the chlorine ion which has been discharged becomes an element of chlorine and this reacts with water forming hydrochloric acid. The acid and base thus formed are made visible by the color changes of the litmus. When the color changes have once been effected, reverse the polartiy of the battery, when the red leg will turn blue and the blue leg will change to red.

The composition of certain ions can be made visible when the ion under consideration is colored. Take, for instance, potassium permanganate which is deep purple in color. This is due to the permanganate ion. Here the negative side or cathode will be discolored and become water white due to the colorless potassium ion; the anode side where the limb is surrounded by the positive electron will become a deeper purple. When the electrical connections to the four-cell plunge battery are reversed, the color in the U-tube goes to the other limb, and the colored side becomes colorless.

Simple Burner

THIS burner may be connected by a bit of rubber tubing to any gas jet or range, and it will produce a small, hot blast. It is very handy in soldering work, and is easily and cheaply constructed.

A short piece of glass tubing is heated and bent to about a thirty degree angle. It is strongly heated at an inch or two past the bend, drawn out, and broken off where the cross-section is about the diameter of a pencil lead. However, this last measurement varies with the size of the brass tube used, and gas supply. The brass tube is made from a cartridge, thirty caliber or more, with the base filed off. It is set in a slanting groove in a block in which it should fit rather loosely so the distance between the glass tube and the cartridge may be varied.



An interesting gas burner for laboratory use, employing a cartridge tube for the mixed air and gas.

The glass tube is held by staples lined with tape with the large end projecting over the edge of the base so that the rubber tubing can be connected to it. Turn the gas on and light it at the upper end of the cartridge. Then adjust the cartridge up or down to secure a hot colorless flame.

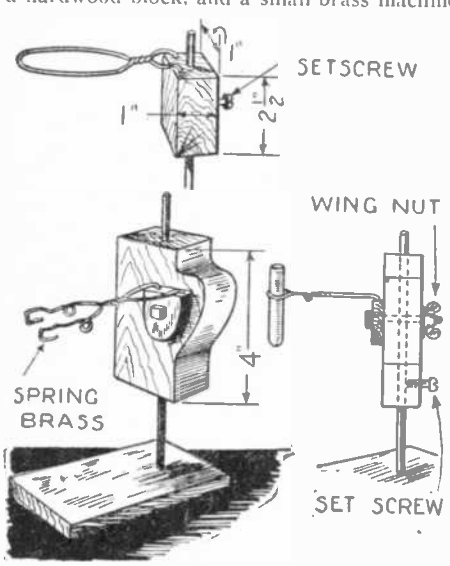
The base may be made larger to include a stand for a soldering iron or a small melting pot, which would increase the usefulness of this simple contrivance.

Contributed by ROBERT ROLLINS.

Ring Stand and Accessories

SEVERAL years ago, when I first rigged up my laboratory, I had occasion to use a ring stand, support rings for a retort, and a test tube clamp. As I had none of these at hand, I made them as described below, incidentally saving a small sum that I used to better advantage elsewhere.

The stand was made of a piece of ⅜-inch brass rod about twenty inches long and fastened to a hardwood base as shown in the illustration. The ring supports were made from a piece of No. 12 gauge copper wire, a hardwood block, and a small brass machine



A very ingenious home-made appliance, which will be of great use in the chemical laboratory, as a test tube holder and ring stand.

screw about ⅛-inch in diameter and about ¾-inch long.

The wire was bent as shown in the figure. A ⅜-inch hole was bored along the axis of the block to accommodate the support rod Two small holes were drilled in the top of the block to make a tight fit for the prongs bent on the wire ring. A small hole that makes a tight fit for the machine screw was drilled at the back. With a good fit this can be screwed up tight enough on the rod to hold the support ring solidly.

The test tube rack was made from No. 14 gauge brass wire, two blocks shaped as shown, and two machine screws, one fitted with a wing nut.

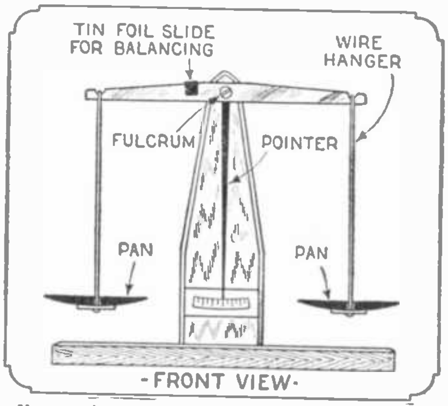
The test tube clamp was fastened to the support rod in much the same manner as the support ring. After the wire was shaped as shown, it was secured to the block fastened to the one sliding on the support rod by the machine screw with the wing nut. This formed a swivel joint and allowed the test tube to be tilted at an angle.

Made with care and finished neatly, they made an attractive addition to the laboratory and served me with entire satisfaction.

Simple Chemical Balance

By W. A. SPERRY

AS can be seen from the drawings and photograph, the balance can be easily constructed from materials easily obtained around the shop or laboratory. For some parts of the instrument, odd or discarded scrap may be utilized, as for instance the aluminum might be procured from cooking utensils—garnered from the ash-heap—or other convenient sources. The beam is made from a fairly heavy piece of aluminum and is cut to the shape shown, care being taken



Front view of a balance which can be used by the amateur chemical experimenter and which weighs with sufficient accuracy for every-day work.

to get it as accurate as possible. Holes are drilled in each end and in the exact center of the beam to accommodate the pan-hangers and the fulcrum, respectively. It is well, however, to cut notches to the end holes in order to facilitate assembling. The central hole might be lined with steel or agate, thus giving a harder bearing surface, the object being to reduce friction at the point of contact, but this is merely a suggestion and is not necessary, since it simply contributes to the efficiency of the instrument.

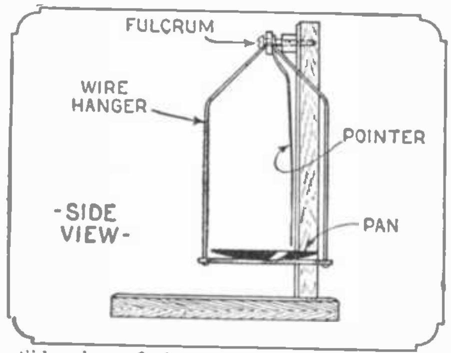
Aluminum of a smaller gauge is used for pans, which are beaten out carefully with a rounded-headed hammer. In order to properly conform to the bottoms of the pans, the rests or receptacles for them must also be made slightly concave. They are cut from sheet copper and are soldered or brazed to heavy copper wire, which form the hangers. Knife edges filed out in the contact area of the hangers rest on the aluminum beam.

The fulcrum is but a rounded-headed wood screw filed to an edge on its shank and screwed to the upright, while a pointer is attached to the beam just below the fulcrum. The upright and base consist of well seasoned hard wood, such as oak, and are accurately made so as to eliminate any inequalities.

In order to improve the appearance of the instrument the little kink suggested below works well.

Any portions which are made from brass or copper can be oxidized black, thus giving to the parts a finished and near professional aspect, especially if the wooden parts are nicely made and carefully polished. Use the following mixture for oxidizing:

30 grs. ferric nitrate.
30 grs. sodium hyposulphite.
50 ccs. water (preferably distilled).



Side view of the balance; the hollow pans and long pointer are here shown clearly.

The parts should be allowed to remain in the solution long enough to give the degree of color desired and are then washed, dried and brushed or hand-rubbed.

The balance was checked by one in the school laboratory and weights were constructed, using the school's set as a standard. It is found that this instrument is sensitive down to about two or three milligrams, and is accurate enough for all general work.

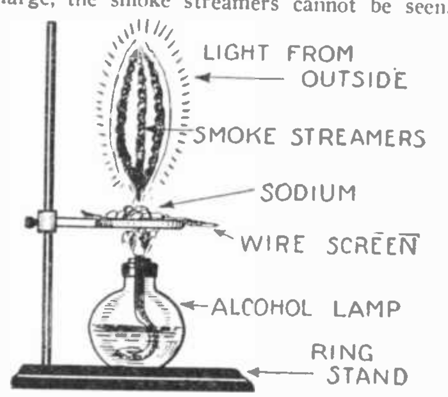
Sodium Smoke Streamers

By W. O. MILLIGAN

A PIECE of wire screen is held over an alcohol lamp by means of a ring stand. A piece of metallic sodium is held in the flame over the wire screen in long tweezers. The sodium will melt and drop upon the wire screen. The oxide on the sodium comes off, and it takes the shape and appearance of a globule of mercury.

In a few seconds the sodium takes fire. It will be noted that the center of the sodium flame is composed of streamers of smoke. All the light seems to come from the outside layer. The light is yellow as all sodium or sodium salt flames are.

If the alcohol lamp is removed, the streamers cease. If the piece of sodium is very large, the smoke streamers cannot be seen.



Interesting experiment with burning sodium; the experimenter must be very careful, however, to keep face and hands away from the melting metal.

After all combustion ceases, a mass of greenish material is left.

Use great care not to approach too near. Keep the face well removed.

A One-Half KW Step-Up Transformer

By C. K. Fankhauser, Jr.

EVERY experimenter would like to possess a high voltage transformer of adequate size. The one described here has been designed carefully, is of high efficiency, and is not difficult to construct. With a primary voltage of 115, the secondary output is 15,000 volts.

The materials needed are as follows:

295 Feet of D.C.C. No. 13 wire for primary.

74,670 Feet of D.C.C. No. 34 wire for secondary.

Annealed sheet iron for core as per Fig. 2.

Two fibre disks 8⅛ inches in diameter and ¼-inch thick.

Five fibre disks 2 inches in diameter and ⅛-inch thick.

About 2 square feet of empire cloth.

Spool of ½-inch linen tape.

First let us take up the construction of the secondary. Great care must be taken to insulate the connections between the six pies of which it is composed and to wind them accurately so as to occupy as little space as possible. Each pie is ¾ of an inch thick. First construct a winding jig or form as shown in Fig. 3. Take two pieces of wood 2⅜ inches square and bevel them as shown so that when the tapered edges are placed together, the two pieces form one piece with parallel sides. The purpose of this is to facilitate the removal of the form after winding a pie. Next take one of the fibre disks ¼-inch thick and one of the ⅛-inch disks and slide them over the form. Spacing them carefully ¾ of an inch apart, wedge the two pieces of wood together until the disks are firmly held in place.

Having placed the form in the lathe, carefully wrap a strip of empire cloth ¾-inch wide around the wood core and fasten the end; varnish or shellac, being careful that it does not stick to the core. The lead running from the start of the winding to the

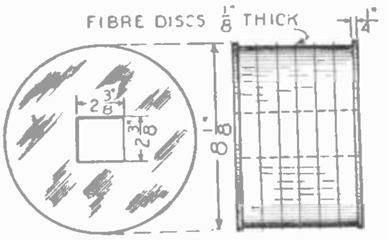


FIG. I

Secondary coil provided with a square core. The secondary coil is constructed of five "pies" or wire separated by fibre discs.

outside of the pie should be protected by a narrow strip of empire cloth folded once so as to enclose the wire. This may be fastened flat against the left hand disc, running radially from core to edge. Allow about three inches for connections. Wind each layer carefully, placing wire close together and evenly. There should be 52 turns per layer for each pie and 164 layers.

When the last layer is completed fasten the last turn by binding with a piece of linen thread. If the winding has been carefully done there should be room left for one or two wrappings of empire cloth.

Before removing the pie from the wood core, clamp the discs firmly together with small iron clamps or pieces of wood with notches cut to the proper width. Then the two pieces may be easily slipped out.

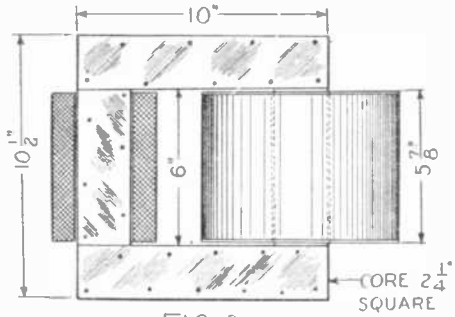


FIG 2

A dimension drawing of the core and the assembled transformer. The core is laminated and should be well bolted to prevent vibrations.

The primary may be wound on the same wood core that was used for the secondary windings. Temporary end pieces four inches in diameter are slipped over the wood core and spaced about six inches apart. Wrap a layer of empire cloth around the core as was done in winding the secondary. After winding on 70 turns of the No. 13 wire push the right hand end piece up tight and continue with the next layer. Seventy turns should make the space between the end pieces approximately 5⅞ inches. As there are only six layers of this winding, waxed paper may be used between each layer. When the winding is completed and the last turn bound in place soak the coil in varnish or shellac and dry thoroughly. After it is dry wrap it with strips of half-inch linen tape, running the tape lengthwise through the core and around the outside. Varnish the wrappings.

The construction of the core is the next problem. It will pay to use the best annealed iron for this. Cut the strips accurately and see that they are flat. Fig. 4 shows the manner in which the strips are lapped over each other at the corners. Allowing 2¼ inches for lapping, the dimensions of the strips should be 7¾x2¼ and 8¼ x 2¼ piled 2¼ inches high. Three legs of the coil are built up first. Give each strip a thin coat of shellac before placing them together. Then clamp them firmly and drill holes as indicated and rivet the layers together with soft iron rivets.

We are now ready to put the secondary in place. It will be noted that the pies were wound with a square hole through the center slightly larger than the size of the iron core. This is to allow for insulation. Cut a long strip of empire cloth 6 inches wide and after putting a coat of shellac on the core where the secondary is to go, wrap tightly with the empire cloth, being careful to have no wrinkles. Enough cloth should be wrapped on so that the pies will fit snugly. As the pies are slipped on, coat the inner sides with varnish. When all are in place clamp them securely together until the varnish is dry.

The protruding ends of the windings of the pies are soldered in series, being careful to insulate each connection thoroughly with tape and varnish. Then wrap the whole secondary winding with linen tape and varnish thoroughly. The primary is slipped on the opposite leg of the core after insulating with empire cloth as was done for the secondary. Then slip the remaining side of the core into place and rivet.

Heavy leads should be soldered to the ends of the secondary winding and these should be kept as far apart as possible. The pie form of winding makes it easier to locate and repair the trouble in the event of the breaking down of the secondary as each pie may be tested separately and the faulty one rewound without necessitating rewinding the entire coil.

If the transformer is to be used for any length of time steadily it should be placed in paraffin oil. For intermittent use it will not heat up enough to make this necessary.

For the experimenter who constructs this transformer the following data relative to its operation will prove valuable:

Primary current, 4.347 amps.

Resistance of secondary, 21,725 ohms.

Resistance of primary, .603 ohms.

Hysteresis loss, 27.28 watts.

Watts loss due to eddy currents, 6.07 watts.

The experimenter who has had no experience with high voltage apparatus should be warned that with a secondary potential of 15,000 volts great care must be taken in operating the transformer. The leads from the secondary should be run to flanged porcelain insulators, mounted on bakelite and spaced at least six inches apart.

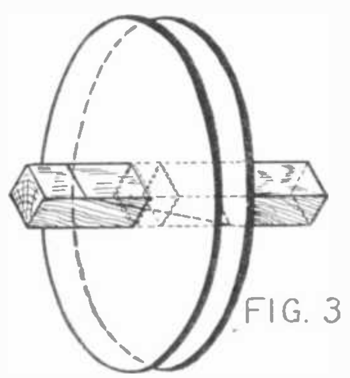


FIG. 3

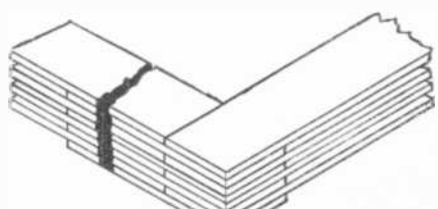
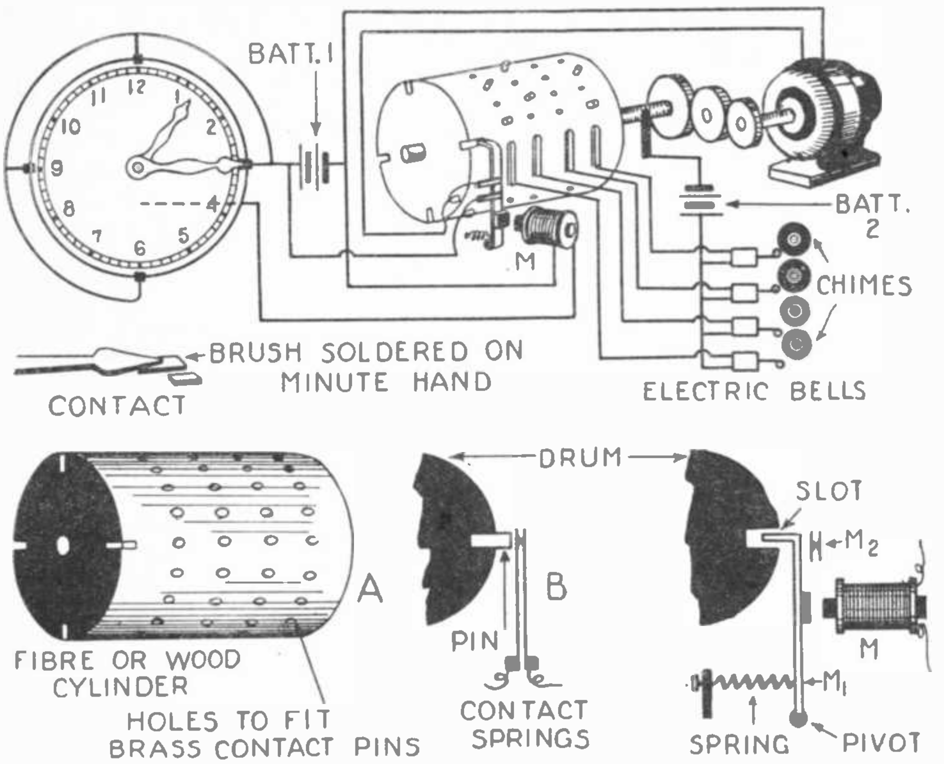


FIG. 4

Fig. 3 illustrates the construction of a mandrel for the forming of the secondary coils. After the coil is wound, the mandrel is readily removed from the center. Fig. 4 shows the structure of the core laminations.

Electric Chime Ringer for Clocks

By H. Winfield Secor



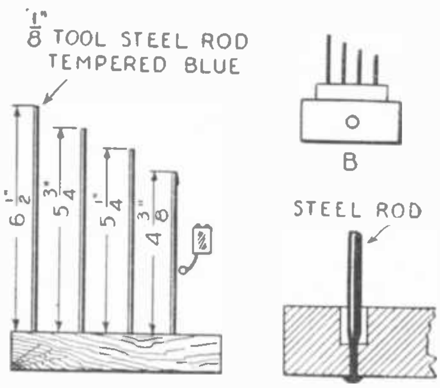


FIG. 2

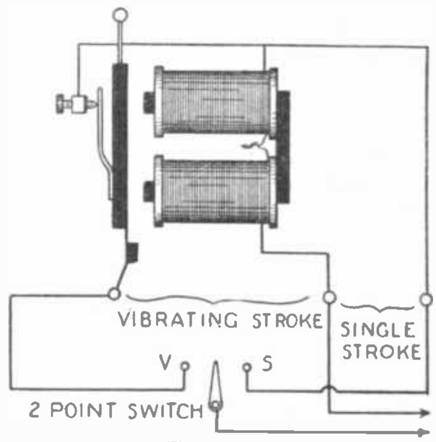


FIG. 3

Fig. 1 shows details of motor-driven revolving drum-switch, playing a different tune for each quarter. When the minute hand makes contact, the magnet circuit is closed, the detent M-1 releases the drum, the motor circuit closes and the drum revolves one-fourth revolution; the detent lever falls into the next slot. This causes the motor contacts M-2 to open; all is repeated at the next quarter hour for a different tune. Fig. 2 shows details for building a steel reed chime, while Fig. 3 shows how to wire bell ringer for single and vibrating stroke.

ELECTRIC chime ringers which may be operated from even the cheapest clock, are of interest to the experimenter, principally for the reason that the cost is low and also because so many variations of tunes can be played on a set of chimes. The ideas given here are more in the nature of suggestions and many other forms of circuit closing and opening devices may be planned to fit individual ideas or requirements.

In the diagram Fig. 1 is shown an electric chime ringer having a revolving switch drum (A). This drum can be made of metal or wood and is drilled with even rows of holes around its periphery as shown, one row of holes being allowed for each chime to be rung; four chimes will require four rows of holes, etc. The electric circuit for the chime ringers, which are electric bells, may be carried through the metal axle of the drum, and thence to a brass sheet covering the drum through which the pin holes are drilled; or if preferred the drum may be made of wood, fibre or other insulating material, and the meal pins inserted in the desired holes to play a certain tune, these pins simply closing two contact springs, as shown at Fig. 1 (B). In this case one spring of each set is connected to a common wire, the second spring of each set being connected to an individual chime ringer. Jack springs serve for this purpose very well, as they are fitted with silver or other suitable contact points.

A small electric battery motor drives the drum through reduction gears, or else through belt and pulleys or by friction drive; the speed of the drum must be very slow, the exact rate being determined by experiment. By inserting a rheostat in series with the motor, and by changing the number of teeth on the gears, the speed of the drum can be brought to any desired value.

The action of the circuit and revolving drum switch shown at Fig. 1 is as follows: As the minute hand of the clock makes contact with the stationary contact placed at, say, 3 o'clock, it would be a quarter after twelve in the picture (first quarter hour strike). The circuit is closed through the magnet (M) which attracts the armature (M-1), and when this happens, the tooth on the end of the armature slips out of the slot in the end of the drum, and at the same time the two contact springs (M-2) just back of the armature are closed, closing the motor circuit. The motor starts to turn the drum and the armature-tooth rests on the outer periphery of the drum as it slowly revolves.

The contact on the clock dial over which the minute hand contact moves should be of the right length, so that the magnet (M) is energized for a sufficient fraction of time, in order that the motor will start to rotate the drum and keep the armature out of its slot until the slot moves past the armature tooth. Also, it will be seen that the contact on the clock dial must be short enough so that the magnet circuit is left absolutely open, in order that when the next slot, a quarter way around the drum, comes under the armature tooth, the same tooth can drop into it and thus open the motor circuit contact springs (M-2). The armature (M-1) is pulled toward the periphery of the drum by a strong spiral spring provided with an adjustment screw, as shown clearly in Fig. 1.

The chimes may be similar to the small cheap sets costing a few dollars, found in the low-priced chime clocks, or if one desires a really fine set they can be procured at small cost from makers of clock chimes. The author will be glad to furnish name and address of a concern making the large chimes, on receipt of stamped and addressed envelope. A set of Westminster chimes with hour striking chime, making five tubes, costs about $25 for the 1¼-inch pipes, and about $37.50 for the 1½-inch pipes.

As shown in Figs. 4 and 5, the chimes may be rung by placing the bell or ringer with its hammer outside or inside the tube. The chimes may also be made from a few wine bottles filled with water to different levels, and the amount of water changed until they tune up well. With a little experimenting one may use steel or brass pipe chimes cutting the tubing into pieces of different lengths. Some chimes have tubes of varying diameters and wall thicknesses. One of the best moderate priced chimes costing $5 to $6 which the writer has seen is a set of

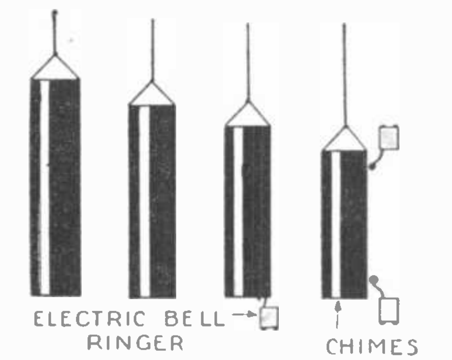


FIG. 4

Brass pipe chimes hung from strings may be rung with electric bell ringers, placing the ringer in the position found by experiment to be best. Several suggested positions for these ringers are shown above.

altar chimes which can be purchased from church supply houses. The ringers or bells, which may be home-made from electro-magnets and odd parts for the armatures may be arranged to ring the chimes with a vibrating or one single stroke each time the circuit is closed. Fig. 3 shows how to arrange the circuits of the bell ringer, so that by means of a switch one can have the chimes ring either way. As shown in Fig. 3 a two-point battery switch readily controls this factor; when thrown to point (V), the bell vibrates, and when thrown to the right or point (S), the bell rings single stroke for each closure of the circuit.

The position of the ringers with respect to the chimes is important, and a little experimenting is the best way to determine the position for each case. Usually it is found best to have the ringer strike the chime near its support.

Details of an actual steel rod chime, which the author has before him as he writes, are given in Fig. 2. This chime is made of ⅛-

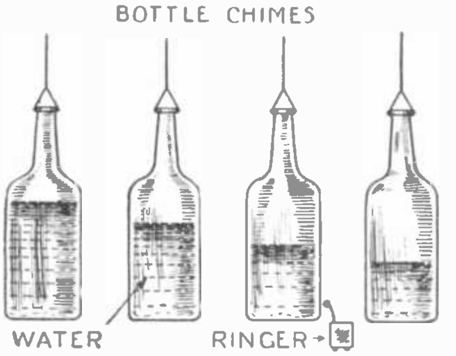


FIG 5

The illustration above shows our old friend the wine bottle chimes, the bottles being tuned for the different notes by altering the height of the water in the respective bottles. The ringer for each bottle chime is placed in position shown for one of the ringers in the illustration.

inch diameter round tool steel rod, tempered blue. Here all of the four chimes are of the same diameter and the lengths are 6½, 5¾, 5¼ and 4⅓ inches, respectively. These steel rods may be held in a small block of hard wood or else set in lead or solder, and the way they are mounted on a cast iron base in the writer's home-made set is shown in Fig. 2 (A). The lower end of each rod is tapered off a little by grinding and is then placed in a hole, the upper portion of which is counterbored somewhat larger than the rod. The end of the rod is then riveted over. All such chimes as these sound best when they are secured to wood, this condition being usually realized by the fact that the chime mounting is screwed to the wooden clock case, and this wooden case acts as a resonator to amplify the sound. The chimes might very well be mounted on a resonator box similar to Fig. 2 (B), cutting a round hole in either end of the box. All joints of the resonator box should be glued so as to make the whole tight, and so that it will vibrate as one member.

Fig. 6 gives an idea for an electric chime clock ringing arrangement whereby the circuits may branch around the house to a set of electrically rung chimes in each room, or

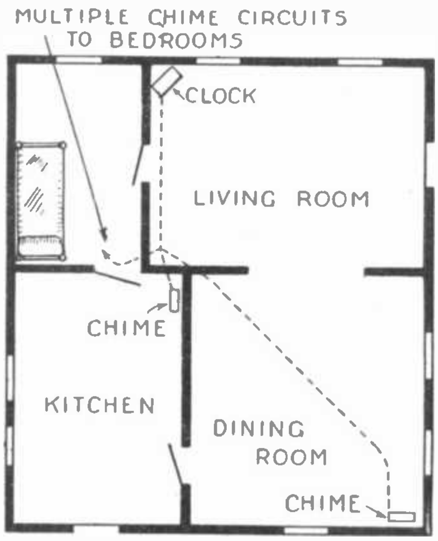


FIG. 6

A master chime clock may be made to play a set of chimes, a different tune each quarter or half hour, as the case may be, placing the different sets of electrically rung chimes in various rooms of the house. The respective ringers are connected in parallel with the main switch wires coming from the clock.

in certain rooms, the master clock being placed in the living room for example, or else in the hall.

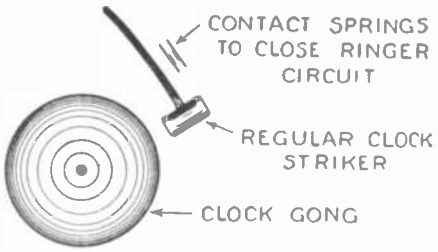


FIG. 7

Where the hour is to be struck with the number of beats corresponding to the hour, the regular gong hammer or clapper on the clock may be caused to close a pair of contact springs, as shown above in Fig. 7; moving the gong so that the hammer cannot strike it, or the hammer may be bent. The contact springs come from an old radio or telephone jack.

Fig. 7 shows how a pair of contact springs, such as those from telephone or radio jacks, may be placed in position so as to close the circuit each time the regular clock striking hammer operates. Some people will be satisfied perhaps to have a different tune played for each quarter hour, judging the time sufficiently close in this way. Others no doubt would prefer to use a fifth chime, or else one of a set of four for striking the number of beats corresponding to the hour just after the tune is finished. The regular clock gong should be removed, or else the striking hammer may be bent so that it does not reach the gong if the time is to be struck on an electrically operated chime. Also, the time may be struck on the regular clock gong if desired, and the tune may be played by an electric striker as an extra feature. The builder of course decides when the tune shall be played, just before the time is struck or right after it is announced by the striking of the hour.

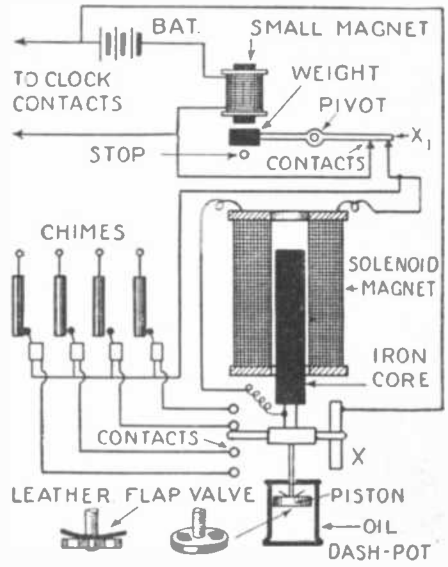


FIG 8

With a set of revolving drum switches controlled by a motor, the experimenter will find it very interesting perhaps to try out magnetic solenoid switches, as shown in Fig. 8 above. Here the upward motion of the solenoid core is retarded by a dash pot, and the main circuit to the ringers is automatically opened as the core and contact arm descend; otherwise the ringers would play in reverse fashion.

An optional method of ringing chimes electrically from any size clock is shown in Fig. 8. Here a solenoid switch is used for each bell or ringer. As the minute hand makes contact with the dial-contact at each quarter hour, the respective solenoid draws the iron core upward slowly, thanks to the oil dash pot secured at the lower end of the core; and as the iron core reaches its uppermost position, it breaks the solenoid and switch magnet-circuit at (X), the weighted switch arm (X-1), dropping open against the stop shown. The solenoid core and switch arm then descend to the lower position ready for the next impulse. When the clock minute hand makes contact, the battery cur-

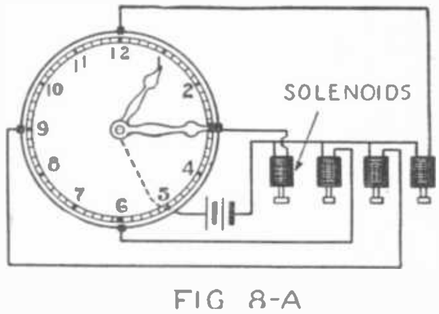


FIG 8-A

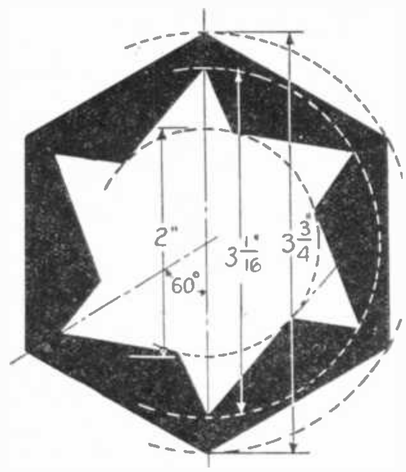
The diagram above shows how four magnetic solenoid switches are connected so as to be operated consecutively at each quarter hour, as the minute hand makes contact with the stationary contacts placed around the dial of the clock.

rent passes through the small switch magnet at the top of the device and closes the contacts at (X-1), which action in turn energizes the main solenoid.

For each solenoid the connection of the wires from the bells or ringers is varied so as to give different tunes. Only four contacts are shown in Fig. 8, but more contacts can be arranged very easily so as to give a greater number of notes, as the contact arm

(*Continued on page 562*)

220 Volt Miniature Motor



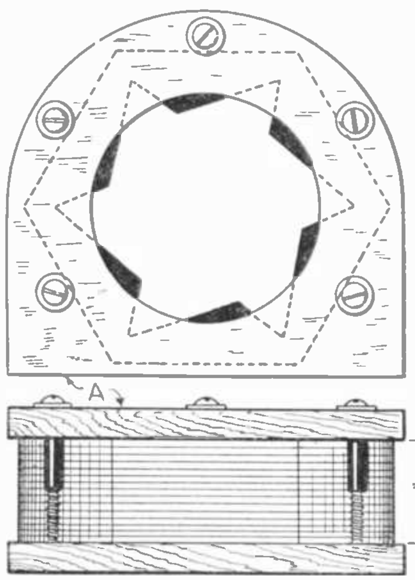
The stator of this 220-volt miniature motor is made up of soft iron laminations of the shape shown in black above.

THE stationary part of the motor, the so-called stator, consists of 50 pieces of soft sheet iron, about 1/50th of an inch thick each, of the form here shown.

Black plates of soft low carbon iron are the best; such iron can be bought in many stores and if there is any trouble in getting it, one can use common tin roofing plate or galvanized iron sheets.

If the outline is first scratched on one plate, with a sharp point, and then is cut out with the greatest care, and this piece is used as a template for cutting out the others, a shears or so-called snips used by workers in sheet iron can be used; but if one does not desire to cut them out himself, they can be easily made by a tinsmith.

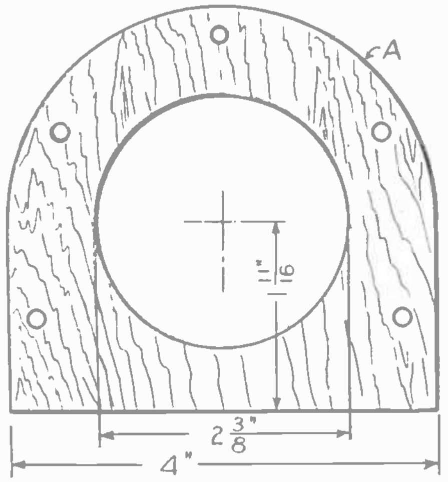
It will be remarked upon examining the diagram that all the cuts to be made are in straight lines, which makes it much easier to shape the stator plates. In cutting out



Assembly of the soft iron stator. The laminations are clamped between two wooden boards by means of large wood screws.

the inner portion, the point of the shears must first be forced through the metal as near the center as possible, and once the clipping begins all will go on without any difficulty. It is merely a question of cutting a number of short straight lines.

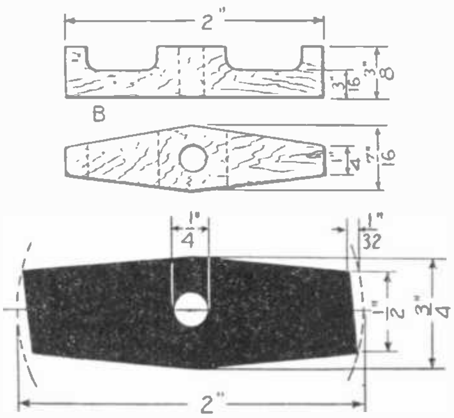
We next show the form of the plates to be used for the turning element of the machine, the rotor. The rotor plates are made of the same material as the stator plates, and one must also prepare here a template, first of all, for the others to be shaped from. The hole for the shaft must be drilled and it is well to drill only a single or a few plates at one time. Then after the plates are put together the hole can be reamed to a true contour. All the plates cut out are carefully filed up to get rid of any sharp



Detail drawing of the wooden frame supporting the soft iron stator of the motor. Large wood screws clamping the laminations are passed through the holes.

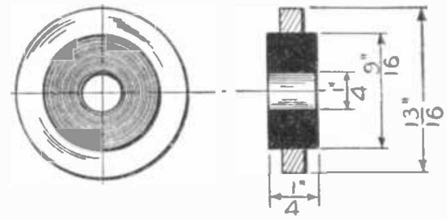
splinter-like points, and then are coated on both sides with shellac or an equivalent varnish.

Next comes the support or frame for the stator. For this, pieces of board of the shape shown above are used; the thickness of the wood ought to be at least ⅜ inch, so



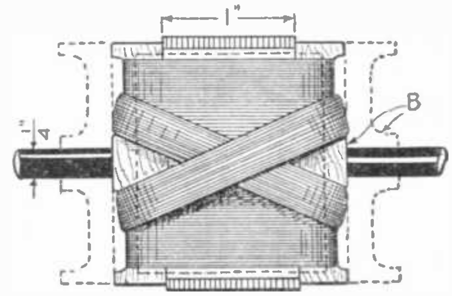
Details of the armature and its wooden clamps of the miniature motor. The lower drawing shows an armature lamination. This peculiar shape is required to carry out the unusual operation.

that the stator plates can be clamped between the boards as shown in the illustration. The two wooden frames or side pieces along with all the iron plates are put in with the greatest care so as to lie accurately one over the other, are to be held in an extemporized frame, and when all is precisely in place they are tied together with



Enlarged view of one of the bearings for the shaft of the rotor armature.

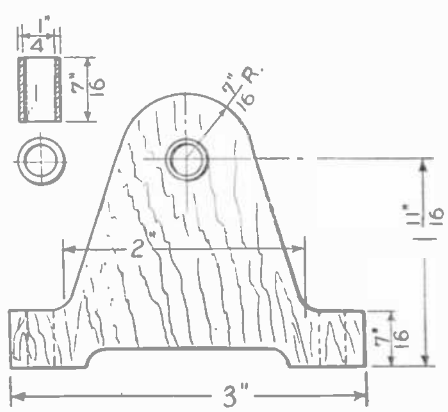
strong thin twine and then the six projections are finally adjusted most accurately to lie one over the other. Finally, the two boards are made to bind all firmly together by five strong round-headed wood screws, with a washer for each. Holes must be drilled for the ends of the screws, so that while they take a firm grip they will not split the wood.



Assembly drawing of the rotor armature and its winding. This armature has a shape peculiar to this motor and not usually found in dynamos.

The rotor plates are thrust upon the shaft, which is to be made of a steel bar or drill rod about six inches long and ¼ inch thick. At the ends of the rotor there are four pieces of wood shown above from two points of view; the idea is to prevent the windings from touching the exposed iron. Paper dipped in shellac is first wound around the plates of the rotor, when they are bunched together. Next, on each end of the shaft one of the wooden pieces is thrust, and the first half of the windings can now be put on as is shown directly below the wooden blocks in the illustration.

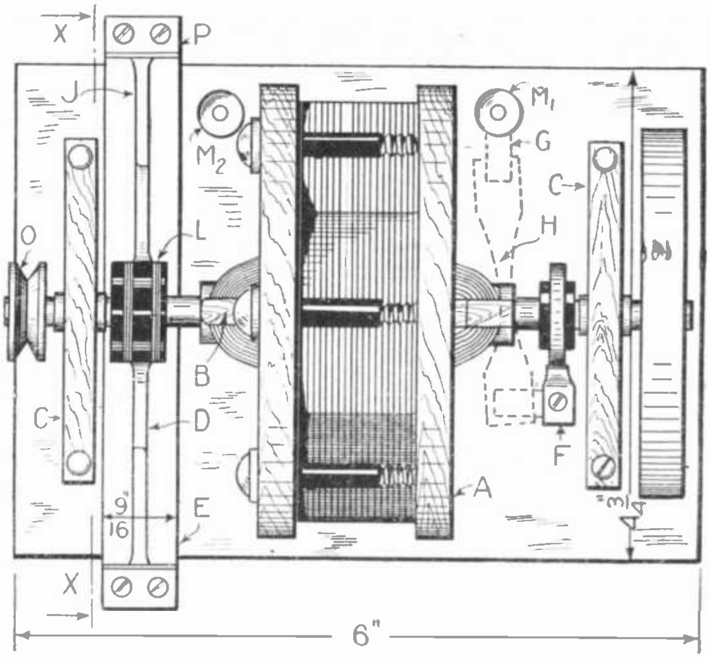
The winding is divided between opposite sides of the shaft, the wires crossing the rotor plates; then all are carried across from one side of the shaft to the other, and the other half is wound. This ensures the firmness of the winding, so that the convolutions lie very firmly in place, and the plates also will be more solidly held. When half of the winding is completed, the other two pieces of wood are thrust over the shaft ends, and a piece of paper dipped in shellac is wound around the first winding; the second winding is then put over the first in exactly the same distribution. If the motor is to be used for direct current, the rotor winding must consist of 3,000 turns of enamelled wire from 1/125th to 1/100th of an

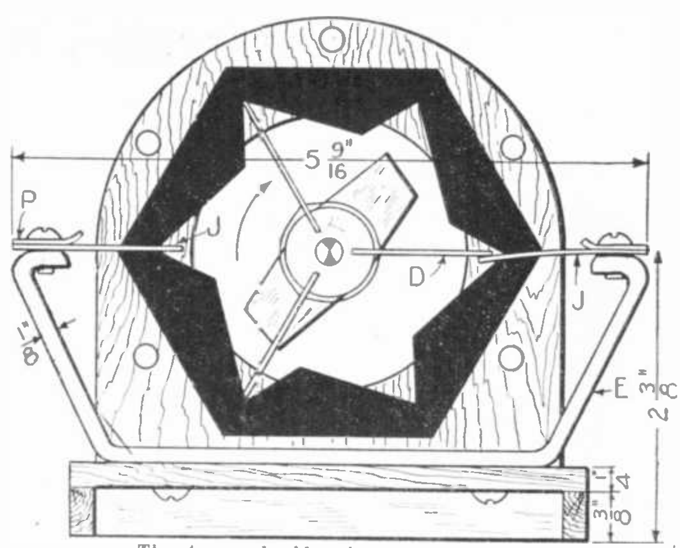


Detail of the bearings. The bearings proper are metal bushings inserted tightly fitting into holes in the top of the wooden frame.

inch thick. For alternating current it is best, although not absolutely necessary, to use a heavier wire, so as to give 1,600 turns of wire nearly double as thick.

Above are shown the bearings, which consist of small pieces of brass tube carried by the support as shown, which is cut out of ⅜ inch wood. The hole for the brass tubes is drilled out a little under size, and is to be filed out afterwards, so as to make a driving fit for the tube. While doing this

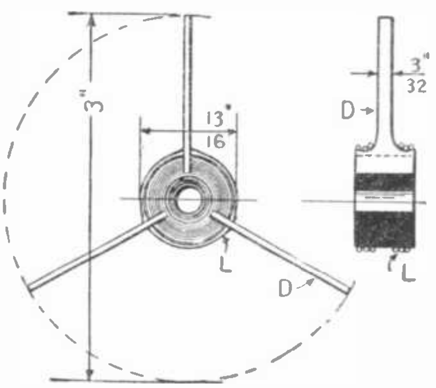




The top and side views of the minature electric motor. The interaction between the peculiarly shaped soft iron stator and the rotor armature causes the latter to rotate. It will be noted that in place of the usual commutator three radial spring strips are employed.

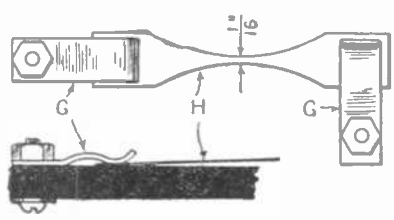
the holes must be worked out at exact right angles to the face of the wood.

On one side of the motor the current is received by a slip-ring. This is a brass ring of the type of a heavy washer. An ebonite or bakelite disc is cut out about ¼ inch thick to fit tightly in the central aperture of the brass washer. In the middle of the disc a hole is drilled which fits the shaft very tightly. The insulating piece is first thrust upon the shaft and then the free end of the wire from the winding is laid over it; then the washer is driven into place so as to jam the wire tightly.



The three contact springs of the rotor and the hub or boss to which they are attached.

We now come to the commutator; this consists of three brass springs which are held in saw cuts in an ebonite hub or ring on the shaft; this hub can be made out of ebonite or bakelite ¼ inch thick by a little over ¼ inch diameter, driven tightly on the shaft. The slots to hold the springs are cut out with a hacksaw, so that the springs can be held tightly when driven into them. When the springs are put into place they are held tightly by bare copper wire, which is wound round and round the hub. One end of the winding of the rotor is still free and this is fastened to this winding of wire.

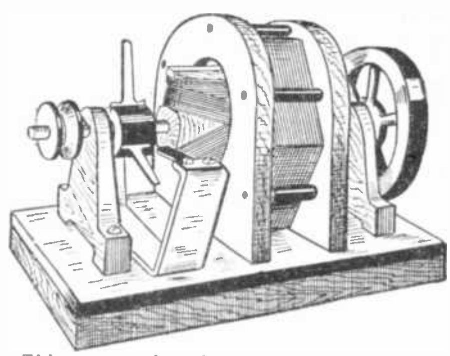


One of the rotating contact springs and its mounting upon slip rings on the shaft.

As the motor is to be driven from a high potential circuit and for safety depends upon its own high resistance, the greatest care must be taken to avoid a short-circuit. A safety fuse can be made out of a piece of tin foil, which is cut down in its center to a width of about ⅜ inch. This is placed under an insulating piece of bakelite or ebonite on the baseboard of a motor. So as to be easily changed in case it blows out, it is held in place by two small brass springs. These are secured by bolts; one holds the single spring or brush, which makes the contacts on the slip-ring as shown on the right hand of the illustration, and the other is clamped fast to the base.

In the next illustration is shown the motor all put together as seen from above; the bearing blocks come outside of all the connections and a pulley is carried by the extreme outer end of the shaft. There is a fly wheel which is hardly necessary, although there are six dead points for each rotation of the rotor. The weight of the rotor, however, will take care of these without a fly wheel.

Above is shown a section following the line X X of the preceding Fig. 10, which shews how the contacts are arranged. The three rotating contact springs strike upon the two contact springs secured by rivets to a solid brass or copper strip, bolted or screwed firmly to the base. In the position shewn there is a contact of the spring (D) with right hand contact piece (J); the arrow shews the direction of rotation and the contact holds for one-twelfth of the turn. After one-sixth of a turn is completed, contact is made at the next point on the left; another spring makes contact with the left fixed spring and so on. For each sixth of a turn



This perspective view of the minature electric motor shows effectively the construction of the commutator and armature.

one or the other of these contacts is made. The relation of the rotor plates to the projecting portion of the stator plates causes attraction which keeps the rotor turning.

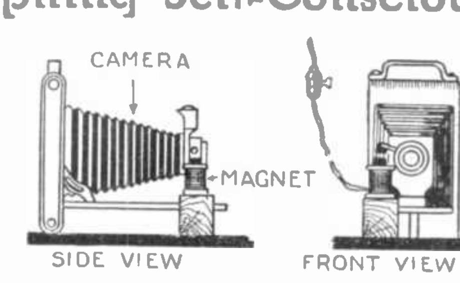
A solid block of wood serves for the base plate, and it is carried by battens or a frame, so that the bolt heads will not touch the table on which it stands. The greatest care must be taken that the rotor winding does not touch the shaft.—*Translated from Illustreret Familie-Journal.*

Photographing Self-Conscious Subjects

OUR local photographer, often finding great difficulty in obtaining good pictures of nervous people used this device.

A lamp socket furnishing 110-volt direct current hung directly over the camera; this was disconnected from the regular switch, although left connected to the main line distant push button.

On the front of the camera was mounted a small electromagnet which was made up of a large number of turns of small insulated magnet wire on an iron core and



A species of trick camera to take a portrait unrealized by the sitter.

was connected to a plug which screws into the socket hanging above the camera.

A small armature was then attached to the finger shutter release in such a position that when pulled down it does not quite touch the iron core of the coil.

A touch on the push button will now actuate the shutter of the camera. In this manner the photographer can make an exposure from the table by touching the button without the subject realizing it until ton without the subject realizing it.

—Contributed by L. H. Prentice.

Hydro-Electric Battery Charging Set

By Willis L. Jones

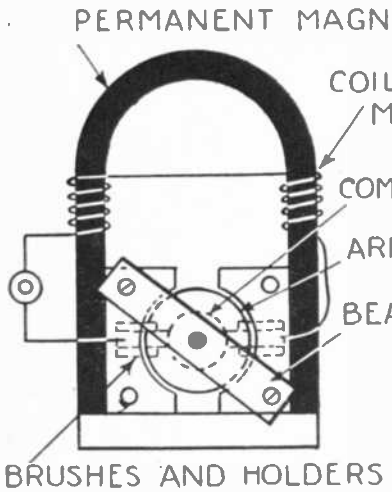


FIG. 1

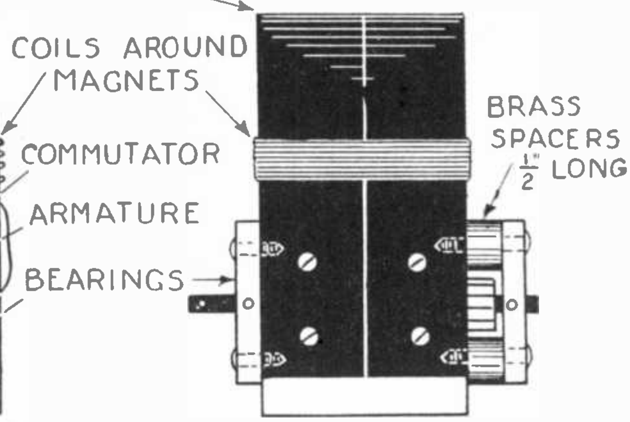


FIG. 2

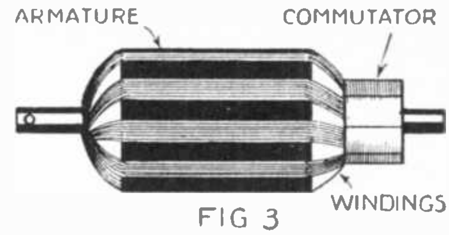


FIG 3

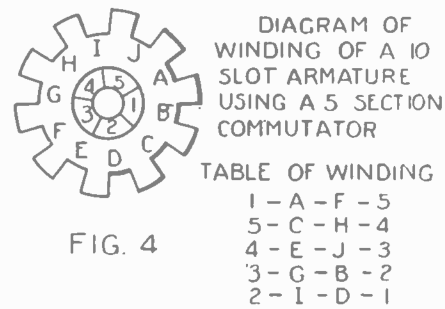


FIG. 4

Figs. 1 and 2 show the end view and side view of the generator to be operated by the motor. Figs. 3 and 4 show the general disposition of the armature with a very clear table for the winding.

TO those experimenters who have no electricity in their homes, or who find a charger too expensive, the hydro-charger will be a life saver. It is inexpensive and easy to make, and if reasonable care is exercised in the making, will operate at full power with a surprisingly small amount of water. Not only has it enough power to run a small dynamo, but it will operate a sewing machine or an emery grinder 6 inches in diameter, 1 inch thick, for sharpening knives, tools, etc.

holes drilled in pairs in the gong for the dippers; each pair are about ¾ inch from the adjoining pairs, making from 18 to 22 pairs of ⅛-inch holes drilled radially around the whole surface. Each set of holes are ⅛ inch from either end, looking at Fig. 7 horizontally. Also on the outer surfact there is a hole drilled of about ⅜-inch diameter. In the diagram Fig. 7 (C) shows this hole, and as shown the dippers on each side should have a surplus of the zinc or iron as represented in (B) and (C), Fig. 8.

anced. The dippers are connected to the gong by brass screws with hexagon nuts; they are ⅜-inch long with a 6/32 thread.

It will be seen that in the center of the gong there is a hole about ¼-inch diameter. On each side about ⅛-inch distant are two more ⅛-inch holes directly opposite each other. Two more ⅛-inch holes should be drilled at right angles to the ones already there to conform with Fig. 7 (D). The shaft which consists of a steel rod 5-inch

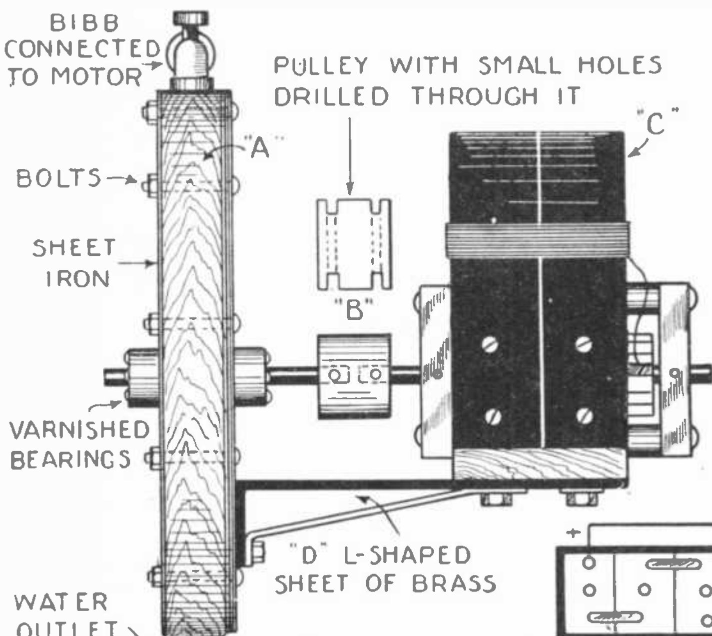


FIG. 5

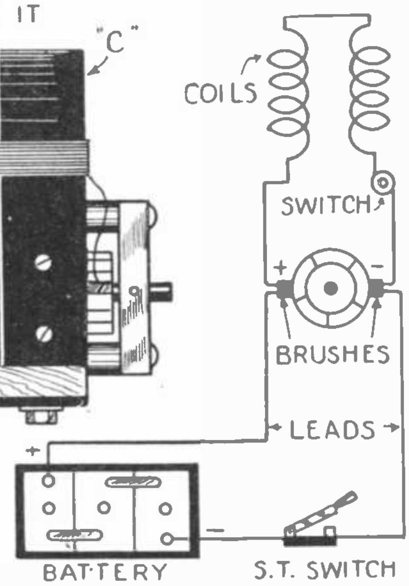


FIG. 6

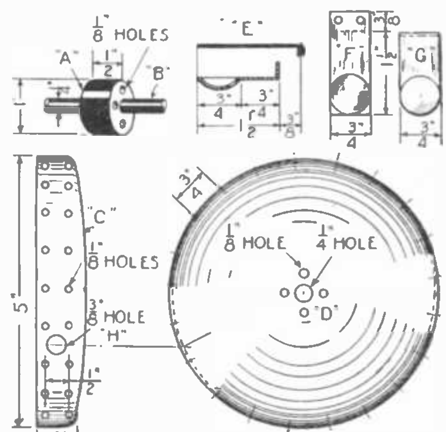


FIG. 7

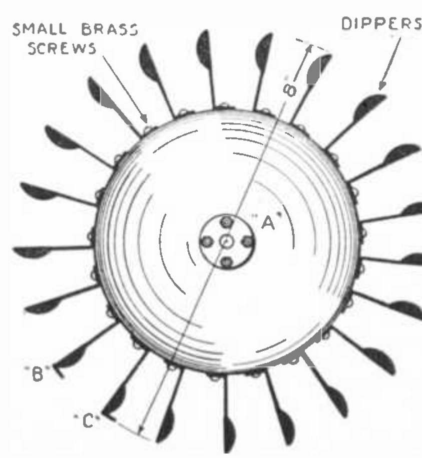


FIG 8

Fig. 5 shows the generator carried on a bracket attached to the side of the water motor. Fig. 6 gives the general layout or hook-up for charging a storage battery. Figs. 7 and 8 show the gongs drilled for the reception of the dippers and also the dippers in place.

The diagram shows practically how the water motor and the dynamo are made, and indicates the materials needed. For fear some points are not clearly understood, I will explain them in full. A gong is used as the basis of the motor wheel. The gong to be used is the kind found in alarm clocks of the Big Ben style and should be at least 5 inches in diameter with the outer surface ¾ inch wide. Fig. 7 (C) shows the ⅛-inch

The dippers should be made of heavy sheet zinc, copper, or galvanized sheet iron; in Fig. 7 (E), (F) and (G) shows how they are made. The curved part is made with a ball peen hammer or with a round head bolt. Dippers (B) and (C) in Fig 8 should be ¼-inch longer than the others as explained above so that the rotor will be evenly balanced. It is impossible to get perfect results, unless the rotor is evenly ballong and ¼-inch in diameter should be brazed to a piece of round brass stock 1-inch in diameter and ½-inch long. Five holes are drilled in the brass rod as shown in Fig. 7 (A). The center hole is ¼-inch in diameter and the smaller ones are ⅛-inch in diameter and should be drilled ⅛-inch from the center hole to conform with the holes in the rotor as shown in Fig. 7 (D). It is then screwed to the rotor with brass screws and nut ¾-inch long with 6/32 thread; thus the rotor is finished.

The bearings for the water-motor are of flat brass or bronze stock 1½-inch or

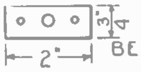


FIG. 10

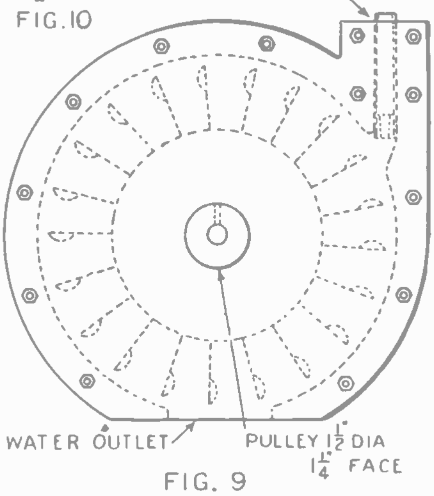


FIG. 9

Side view of the hydro-motor with dotted profile of the gong and dippers, and the bearing for the shaft is shown in the upper corner.

2-inch long, ¾-inch wide and ½-inch thick as shown in Fig. 10. The frame is made from a square block of wood thoroughly soaked in oil. In Fig. 11 is shown how the block of wood is prepared after being thoroughly soaked in oil.

After the wood is finished and the holes are bored as shown in Fig. 11 (C), the next step is making the side walls which are very simple and easy to construct. They are made

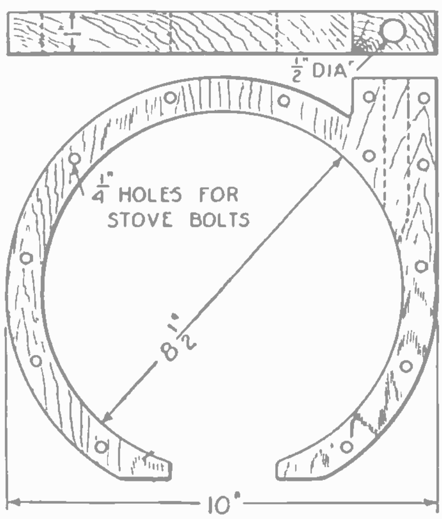


FIG. 11

Diagram of the wooden separating piece for the water motor. This with two side pieces such as shown in Fig. 12 makes the chamber for the rotor wheel.

from galvanized sheet iron which can be bought for a few cents at any hardware store.

Hold the wooden block, Fig. 11, on the iron and draw an outline to conform with its outer dimensions. Also drill the required holes by using the holes of the block as a template.

Now push the figure aside. Cut the iron along the line thus obtained and when the cutting-out is finished, drill a hole ¼-inch or 5/16-inch through the center of the finished side wall. By using this one as a pattern the required number can be produced in quick order; also after boring the center hole, it is best to bore the holes for the bearing; that is, the two holes opposite the center holes for the bearing screws. If the generator is to be operated by a pulley and belt, two side walls are enough, but if it is to be connected directly to the water motor as shown in Fig. 5 (D), then it is best to double or triple the walls on the generator side of the motor, as the weight of the electrical machine is too heavy for a single thin side wall to carry. If the machine is to be connected thus, three holes should be drilled in the generator side of the water motor to hold the heavy "L" shaped piece of brass or bronze shown in Fig. 5. The generator is screwed to this as shown in the same diagram.

After the side walls are completed and the bearings are attached by means of brass screws ¾-inch long with 8/32-inch thread, the next step is the nozzle. It is made from a piece of brass tubing about 2½-inch long with the outside diameter about ½-inch. A piece of solid brass stock about ½-inch long and just thick enough to fit snugly in one end of the tubing is obtained and brazed there. Now drill a 3/16-inch hole through the solid brass piece; take the tang of a file, the part that goes into the wooden handle, and ream the hole just made until the bottom end will be ¼-inch diameter and the upper part about 1/16-inch diameter; in other words, you have a cone-shaped hole with the smaller end at the bottom. This hole can be made in the solid stock before it is brazed on if the experimenter so desires. At the other end of the tubing a brass ring with an inside diameter of ½-inch and the outside slightly less than ¾-inch, with a thickness of about 3/16-inch, is brazed on for the bibb connection which can be bought for a few cents or taken off a piece of discarded hose. Fig. 13 shows another method of connecting the nozzle to the bibb. This is an easier way; the hose is connected to the bibb and the free end is forced over the nozzle as shown in the illustration.

After the nozzle is finished the motor is ready to be assembled. Thoroughly varnish the wooden frame and the outside of the nozzle. Placing the rotor in the center of the wooden circle, assemble the motor, gradually tightening each screw, until all are home. It will be found after the varnish is thoroughly dry that the nozzle holds firm and that the motor is waterproof and that no water leaks from between the side walls. On the top side of the water motor's bearing there should be drilled a small hole about 1/16-inch in diameter for the oil. These holes, one on each bearing, are drilled in the center of the bearing just over the shaft of the water motor. Our motor is now finished, and if it is connected to about 50 lbs. water pressure, it will develop a tremendous amount

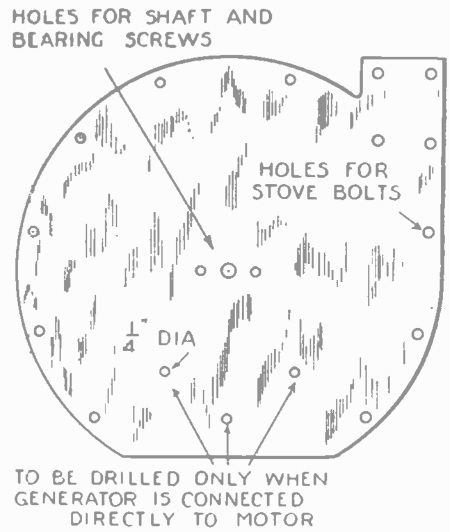


FIG. 12

The side piece closing the chamber for the motor, fitting upon the separator shown in Fig. 11. There are two of these, one for each side.

of power. Fig. 11 shows at the bottom the water outlet, which is taken care of by cutting the wooden block as shown in the same diagram.

The next operation is to make the generator, which is not a difficult job. The illustration explains it clearly. The generator is made from an old magneto which can be bought for a few cents at nearly any garage or second-hand shop. Even if the magnets have lost their magnetism, the generator will operate. The first step is to discard

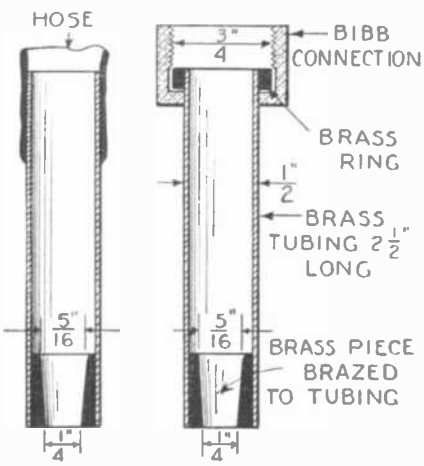


FIG. 13 FIG. 14

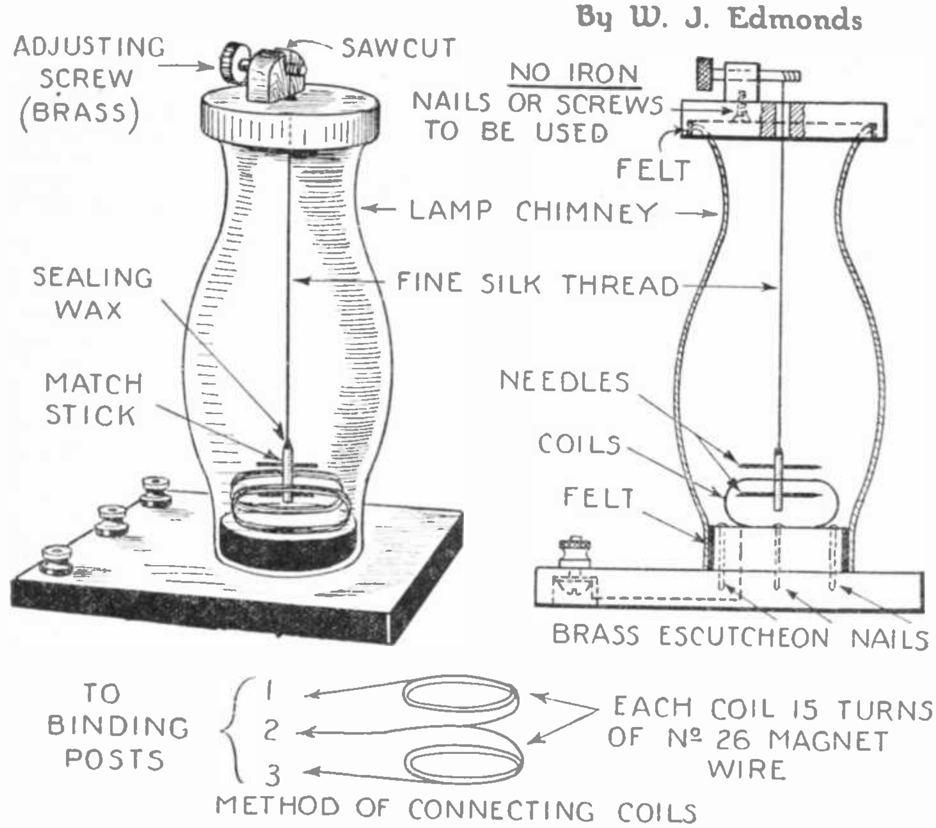
Nozzles, one for receiving a hose connection, the other for a bibb connection for driving the hydro-motor. They fit the hole in the upper part of the casing.

the two-pole armature as it is of no use. No doubt the bearings of the magneto will have to be discarded, as the shaft of the armature of the magneto is larger than the shaft of the ordinary drum armature, the kind to be used in this machine. Therefore, the holes in these bearings would be too large. Fig. 1 shows how the bronze bearings are

(*Continued on page 562*)

Astatic Galvanometer

By W. J. Edmonds



An unusually simple astatic galvanometer may be constructed as shown above. An astatic galvanometer has an advantage over the ordinary galvanometer in that it is not influenced by the earth's magnetic field. Two magnetized needles are employed disposed in opposition to each other so that the turning forces on the two needles due to the earth's field are neutralized.

A VERY simple and sensitive galvanometer, which consists of a pair of magnetic needles, suspended one above the other with reversed poles (astatic needles), on a silk fibre between two coils of wire and protected from stray air currents by a common oil lamp chimney, may be easily constructed by any experimenter from the odds and ends usually found around the average experimenter's workshop.

By examining the illustration the constructor will gain a clear idea of the simplicity of the instrument and will be more fully prepared to construct one. The base for the instrument is made of wood of a size to suit the builder. At one end three binding posts are located, which are connected to the two coils secured to the sub-base at the opposite end. This sub-base is a disc turned from wood, and has a diameter ⅛ of an inch less than the interior diameter of the lamp chimney which it holds upright as illustrated. A single thickness of felt is glued around the circumference of this piece, which is sufficient to securely hold the chimney in place without other means.

The top piece is also turned from wood and has a recess turned in its inside surface about ⅛ of an inch larger in diameter than the diameter of the chimney top, so as to permit the gluing of a thickness of felt to same for the same purpose as the strip of felt on the sub-base. The depth of this recess is about ¼ of an inch. Exactly in the center of this top a 3/16-inch hole is drilled entirely through to permit the silk cord carrying the needles to pass from below to the adjusting screw on top. On the upper surface of the top and a little off center of same a block carrying this adjusting screw is secured with glue and with a brass wood screw. No iron can be used anywhere. Near the top of this small block a hole is bored through the block slightly smaller than the diameter of the adjusting screw and a saw cut is made from the top of the block to the hole. The adjusting screw is simply a piece of round brass rod having a disc of brass soldered to one end to provide a thumb piece.

Two small flattened coils of 15 turns each are made up from No. 26 magnet wire and secured to the sub-base as shown, by means of a small brass strap held in place by two small screws. The different turns of these coils are bound together by coating same with an insulating varnish such as shellac, collodian, etc. The needles consist of two ordinary sewing needles inserted through a match stick as shown. The needles pass through the stick so that they are parallel. A very fine silk fibre is obtained and one end of this is fastened to the upper end of the match stick carrying the needles by means of a small drop of sealing wax. The other end of the silk fibre passes vertically through the chimney, through the top and is fastened to the end of the adjusting screw.

The sensitiveness of this instrument will depend entirely upon the fineness of the silk fibre, otherwise it would take a very heavy current passing through the coils to affect the needles.

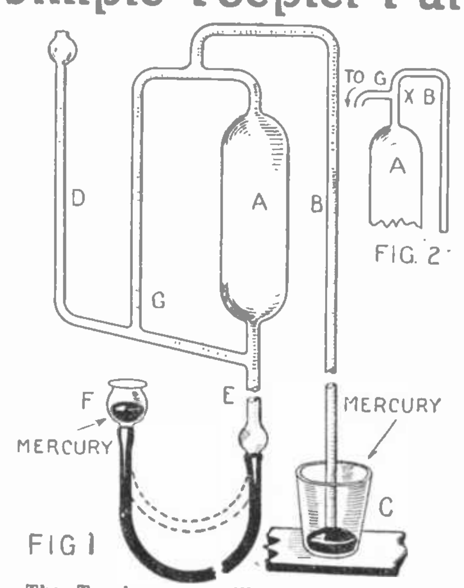
The method of connecting the coils as shown is used so as to permit the use of either coil independent of one another or of both together as desired.

A Simple Toepler Pump

A PUMP producing a good vacuum is a very useful item in an experimenter's laboratory. The Toepler pump has several advantages and is not very expensive. It suffices for all cathode ray experiments that the enthusiast may wish to carry out.

Fig. 1 shows the general construction; the whole pump is made of glass. The receptacle (A) is of about 200 cc. capacity and the other members are of barometer tubing. (B) is extended down to a mercury reservoir (C) length from the surface of the mercury to the top of (B) being 760 mm. The vessel to be exhausted is attached to (D) and a length of pressure tubing connects the mercury receptacle (F) to (E). A glass blower will make the whole thing for $5.

Assuming the pump to be set up and that (F) and (C) contain mercury; connect (D) to the vessel to be exhausted, with a short length of pressure tubing. Raise (F) until mercury flows down (B) and so expels all the air from (A). Now lower (F) slowly. The mercury in (A) falls, creating a Torrecellia vacuum as soon as the difference in height between (F) and the top of (A) is greater than 760 mm. When the mercury descends nearly to the bottom of (G) the gas from (D) connected to the vessel to be exhausted, rushes up (G) and down into (A). On again raising (F) the tube (G) is sealed and the air is expelled through (B). This process is repeated again and again until a vacuum sufficient for the purpose has been created. An indication of the vacuum in the vessel may be obtained by lowering (F) until the mercury drops below the point (G). The height of the mercury column in (B) compared with atmospheric pressure (approximately 760 mm.) gives one an idea of how far the process has gone.



The Toepler pump illustrated above is a slow but efficient high vacuum pump. In operation gas or air is taken from a vacuum tube or other receptacle to be exhausted in through (D) into (A) from which it is expelled by mercury when the reservoir (F) is raised.

Of course, unless the experimenter has an unlimited supply of mercury he will have to occasionally transfer some of the liquid metal from (C) to (F). It is therefore convenient to make the reservoir (C) a bottle with the top to the bottom. The tube (B) may enter through a cork, but another hole must be left in the cork for the gas to escape as it is pumped over.

The form described is a modified Toepler pump. The original pump was made as shown in Fig. 2. The disadvantage of the original form was that on beginning to exhaust a vessel the mercury passing from (G) to (A) by reason of the difference in pressure had a tendency to fracture the glass at X.

J. R. NEWSON.

Tapped Transformer

By Emil J. Schau

IN building a transformer, the experimenter should keep in mind that such a device ought to be made with a view of providing as great a number of different secondary voltages as is possible. Where only one fixed secondary voltage is desired, as in operating door bells, low voltage lamps or similar devices, the transformer may be made the usual way, but for an all-around supply of miscellaneous voltages for experimental work, a transformer of the tapped type is preferable.

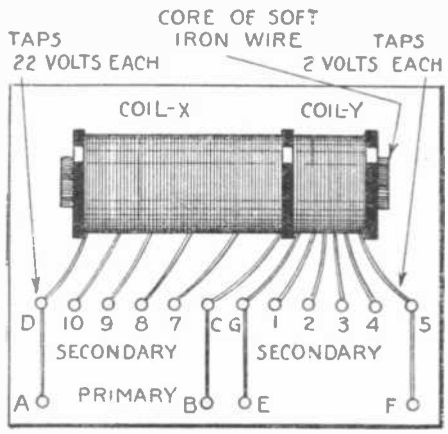
A transformer, having a fixed secondary voltage, may have this voltage varied by means of the voltage drop in a variable resistance (rheostat) or by means of a variable reactance coil.

A rheostat limits the current by offering resistance to its flow. This involves large loss of energy, which is expended in heating the rheostat and is therefore doing no useful work.

A more efficient device in regulating the single secondary voltage of a transformer is a reactance coil. The one drawback here is that when current of several amperes is drawn off the circuit, the coil will be so large and the cost of the heavy wire so great, that the reactance coil scheme is ruled out of the question.

Assume that the transformer is required to give 120 volts in steps of 2 volts and that it is to combine the advantages of having a secondary separate from the power circuit for low voltages with high currents, and the economy in copper wire of an auto transformer for high voltages.

The scheme of connections is shown in the illustration. A and B are connected to the house lighting circuit, and the circuit A—coil X—B constitutes the primary side of the transformer. The secondary side of the transformer is D—coil X—C and is



The illustration shows a transformer which combines the advantages of the auto-transformer, and the ordinary two-coil transformer. With only ten taps the voltage on the secondary can be varied from 2 to 120 volts in steps of two volts.

tapped off at every 22 volts, giving 5 taps. The coil Y is an extra secondary and is wound separately from the main coil, and is tapped off at every 2 volts, giving 5 taps. This coil Y may be wound either directly over the main winding or on a separate leg or on an extension of the core, and is to be wound with extra heavy wire treating it as a regular step-down secondary, capable of delivering large currents at low voltages. Winding Y used in conjunction with winding X will give the broad voltage range.

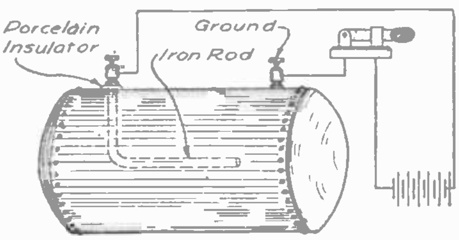
The wire in coil Y is wound in the same general direction as the wire in coil X. With A and B connected to the power circuit and lead E connected to lead B, the voltage induced in coil Y will be added to the voltage induced in coil X; but if lead F is connected to lead B, the voltage induced in coil Y opposes or "bucks" that of coil X, and the resultant voltage is the difference between the induced voltages of the two coils.

With A and B connected to the power circuit the voltages from 2 to 10 are taken off the auxiliary secondary winding Y by connecting a wire to G and clipping the proper taps 1 to 5, depending on which voltage is desired. For voltages from 12 to 22 connect a wire between F and B. Clip a lead on tap 7 and another lead on taps 1 to 5, depending on the desired voltage. In this instance the induced voltage of the tapped portion of coil Y is opposing the induced voltage in the 22 volt section of coil X. For voltages from 24 to 32 connect a wire from B to E and clip one lead to tap 7 and another clip on one of the taps from 1 to 5. For voltages from 34 to 44 connect a wire from B to F and clip one lead to tap 8 and another clip on the particular tap from 1 to 5. This scheme if continued will give the desired voltages from 2 to 120 in steps of 2 volts.

If desired, the transformer may be mounted inside a cabinet bringing the taps to 3 switches on a panel. Care must then be taken that the switch lever shall be so narrow that it will not short circuit two switch points in changing from one point to the next one.

Electrifying Boilers

A METHOD of preventing boiler scaling is described and illustrated here, which is said to be applicable to kettles, or coffee urns in restaurants, even to very large ship boilers.



Electric current is maintained within a boiler and is supposed to prevent formation of scale thereon by electrolytic action. The iron rod must be replaced occasionally as it oxidizes.

When a kettle has been used some little time, bits of scale will collect and drop from the metal sides of the vessel. This prevents the water from boiling as quickly as it should. The same thing happens with large steam boilers. Every month or so in bad cases these boilers have to be scaled on the inside with a scaling tool, to chip all the attached scale off, which is a slow operation.

The new idea, which is already being carried out on some large boilers with success, operates on low voltage between 6 to 10 volts and with a current of 12 amperes. The principle is the same as in a nickel-plating set, but the negative wire is grounded, while the positive runs to the iron bar which is supported below the surface of the water, and is insulated from the boiler shell. This iron bar collects the scale and prevents rust, also purifies the water. After a time it is removed and a new one put in its place.

Contributed by Roy E. Hopkins.

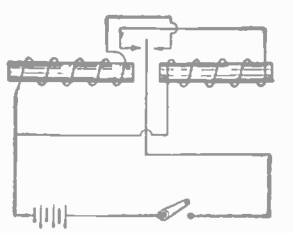
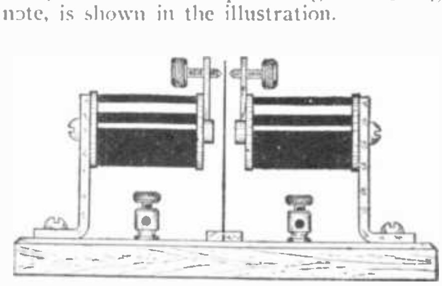


Diagram of buzzer showing wiring and general connection.

Double Contact Buzzer

A DOUBLE contact vibrator for a buzzer which eliminates sticking contacts, spring troubles and other sources of annoyance, in addition to producing a fine high note, is shown in the illustration.



Accurately operating buzzer with double contact, capable of most delicate adjustment.

It is an instrument easy to construct, on account of its simplicity. Special care in making the vibrator will insure good vibration. The contacts may be made of silver, platinum or other metals which will not burn out.

The coils are of the common bell-ringing type. The adjustment is made by the contact thumb-screws. The coils are supported on metal brackets bolted to a wooden base.

Sometimes to prevent an armature sticking by residual magnetism, a piece of paper is cemented to it or to the pole of the magnet, so as to prevent the metal of the armature coming in contact with the metal of the magnet core. In this buzzer a more elegant method is used to prevent sticking. The two adjustable screws are set so that metal never touches metal.

Contributed by Clayton Robinson.

JUNIOR EXPERIMENTER

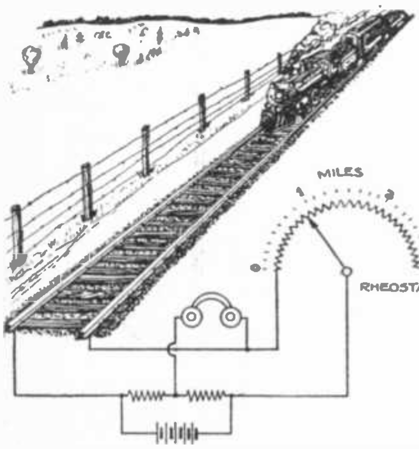
More Experiments

By Esten Moen

SAY, you and I was doin' some 'sperimentin' awhile back, wasn't we? Funny how we start a thing and then neglect it, hey? Well, I been thinkin' it over and thought it'd be a fine thing if we get together again.

Maybe you'd like a gauge to tell how many miles up the railroad track a train is. Hey. don't throw away your old rheostat—use it as shown in Fig. 1. A sort of Wheatstone bridge, or "ohm meter" or "what-chu-call-it."

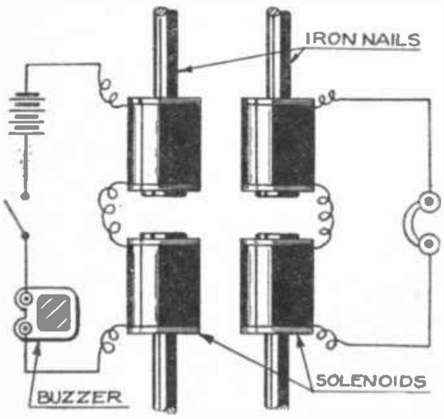
Maybe you're interested in "short wave radio"? Here's your chance—grab Fig. 2. Two big iron nails—separated or joined (as you like it)—with a pair of solenoids. That's



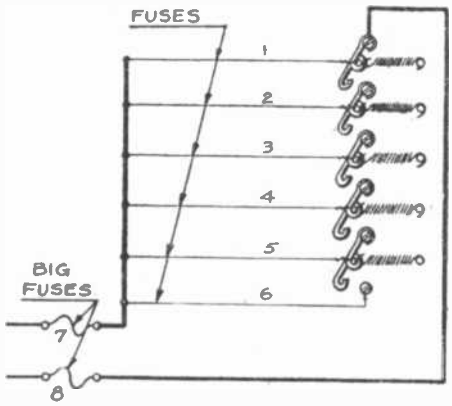
This Wheatstone bridge arrangement will enable you to determine the distance at which the approaching or receding train is located at any moment. A rheostat is adjusted until the sound in the receiver is at a minimum.

all. Say, ever hear of the "phoney telegraf patent"? The inventor planned to use an iron wire line between each station, all right—but he figured (the bloomin' cuss) on usin' the line as the core (get me, "solenoid") of a huge (Dachshund) sounder! Whew—wonder if magnetism would travel so far. Hey, I don't mean to insult you with degenerate nonsense; let's pass on.

I s'pose you got a dinky bell-ringing transformer lying idle. What can't you do with it? See Fig. 3. Rig up a windmill to drive



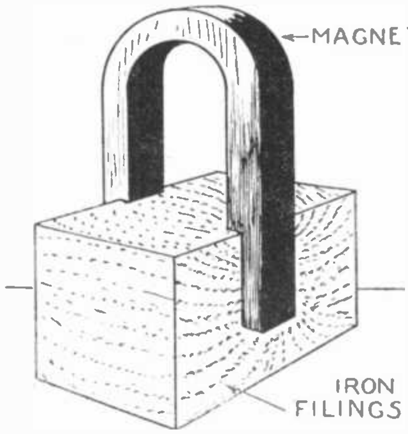
This is a form of wireless communication, though of course effective only over a distance of a few inches. Pulsating current in the coils on the left induces an e.m.f. in those on the right.



The author suggests that by employing fuses of successively greater size, the fuses arranged as shown, will "blow" in succession.

your telephone magneto—too simple, eh (or hard to make, hey?). Just hold your horses—I'm gonna spill somp'n.

Fuses! How many have you blown? Remember the first you "blew"? Ever hear of "musical fuses"? Once I had an idea that if I could blow fuses in fast enough succession, it'd be possible to produce a musical note! (And a loud note, too, I'll tell the cock-eyed world.) So I up and at it. The completed model resembled Fig. 4 Fuses Nos. 6 and 7 were twice as large (in amp. capacity) as 1, 2, 3, 4 and 5. What happened? Why, the two big fuses (6 and 7) blew before No. 2 had a chance to melt! And why? Because of delayed extinction of arc caused by first fuse.



A neat paper weight for the experimenter. Iron filings sprinkled on the sides of the block are permanently fixed by the application of shellac or paraffine.

The Good Old Days

'Twas recently my pleasure to invade the New York Public Library. Books! I guess this house had a monopoly on books.

For three days I "lived" on the glorious good old Electrical Experimenter from Volumes 3 to 7. Oh, boy! I've read letters in *Science and Invention* that "kicked" H. Gernsback for not continuing this magazine—and I sympathize with the kickers.

One day I picked up an old volume of a paper, "The Electrician" (London).

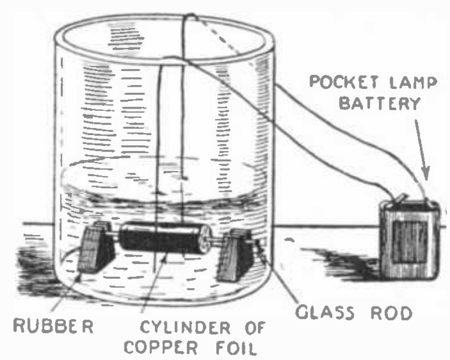
Quite frequently in those old papers is seen the word "telemachon." What the deuce d'you suppose it is—some infernal machine? Guess again. Why, it's just your old friend—just the plain—dynamo (same on you).

Mysterious Cylinder

By Dr. Alfred Neuburger, Berlin, Germany

DISSOLVE some crystallized copper sulphate in water and pour this solution into a glass. Make a small cylinder of copper foil and close its end by well fitting plugs made of wood or of vulcanized India rubber. The cylinder is put into the solution of sulphate of copper and water in a way to dip in fully and to be easily revolved. Wires inserted in the plugs form the pivots.

The cylinder must be most accurately centered and balanced. A thin small glass rod serves as an axis which turns in two bearings. They are formed by two small pieces of vulcanized India rubber put into a glass, first filing out small angular notches on their tops. Now we connect a copper wire to each pole of our pocket-lamp battery. The free ends of the wire dip into the solution



A copper cylinder immersed in copper sulphate solution will rotate when electrodes connected to a small battery are set as indicated. A rotation is caused by the unequal loading of the cylinder due to the deposition of copper on one side and solution from the opposite side.

so that they are opposite to each other in the direction of the diameter of the cylinder. The cylinder must stand exactly vertical to the connection line of the wire.

Now we will see something most astonishing. Suddenly the cylinder begins to turn round, quite on its own account and continues its rotations as long as a current passes through the liquid. Why so? If we dip both the wires only into the solution, a layer of copper will thicken one of them soon, as the solution of copper is acted on by the current depositing copper. But when we immerse the cylinder of copper foil in the path of the current so that the latter must pass through, copper will be deposited on one side of the cylinder and will be dissolved from the other. About as much copper as is deposited on one side will be dissolved from the other side.

On account of this the cylinder gets heavier and heavier on one side and lighter and lighter on the opposite side, and it begins to revolve as the heavier side must needs try to sink down. Thus, a new area of the side comes to the place where copper will be deposited on it and a new spot gets lighter again. For this reason the revolving movement goes on. Moreover, we used a rather concentrated solution and succeeded thus in almost floating the cylinder, reducing the pressure and consequent friction on its axis. That is why the smallest addition of weight on one side is sufficient to make it revolve.

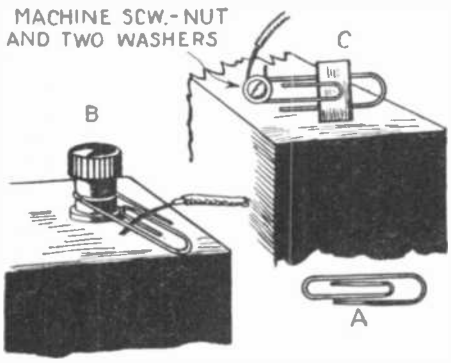
Paper Clips as Battery Connections

By Leonard F. Russell, Brighton, Eng.

IN the process of testing small electrical instruments, it is very often necessary to connect wires to and remove them from the battery terminals two or three times during the course of the operation.

This is not only irksome, but is also likely to fray and break the wire at the part where it is looped round the terminal.

To obviate this an ordinary large sized paper clip, of the type shown at (A) in the illustration can be utilized; it is connected



Many forms of terminals are adapted to rapid connection and disconnection by the use of the ordinary paper clip is illustrated above.

to one of the terminals of the battery and the wire is clipped in as shown at (B).

The clip holds the wire firm and makes a good connection without bending or fraying it; it can be disconnected again with the greatest ease by pulling it out of the clip.

Batteries of the flashlight type can be connected up to any instrument by bending the wire into a permanent loop and clamping it to a paper clip by means of a machine screw, nut and two washers.

The clip can then be slid over the brass strip which takes the place of the usual terminal in this type of battery as shown at (C).

Useful Electric Toy

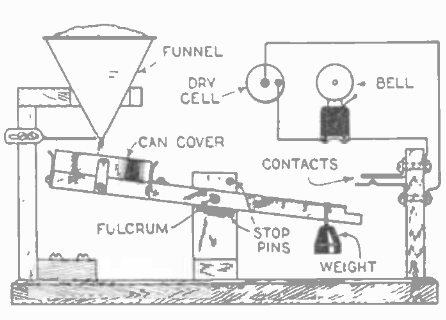
ANY handy boy can build this inexpensive electric toy, which incorporates the principles found in the hour-glass and in the balance. Primarily designed for the purpose of amusement, it has been termed a toy, but it has a wide range of usefulness as a practical device for timing culinary operations, photographic exposures, etc.

A wooden lever is mounted on a fulcrum support. This support is screwed to a baseboard and is provided with two stop pins that limit the movement of the lever. One end of the lever is notched and a movable weight is hung on it as shown. A cover of a baking-powder can is set on the opposite end and is held in place by spring clips. A wooden bracket holds a funnel directly above the cover. It is necessary that the outlet of the funnel be very small. A sliding piece of tin serves as a shut-off valve. On the opposite end of the baseboard, an upright holds two brass contacts. The upper one of these is made of fairly heavy ribbon brass and the lower contact of light spring stock. A bell or miniature lamp is wired to the contacts as indicated.

Dry sand is poured into the funnel and the weight is set at some predetermined point on the notched end of the lever. When the valve is opened, the sand will run down into the can cover in a small stream. When enough sand has fallen to make the combined weight of the cover and sand more than counterbalance the fixed weight, the notched end of the lever will swing up. The end of the lever will hit the spring contact and cause it to meet the upper contact. This completes the bell circuit and sets off the alarm.

It can be readily seen that the further away the weight is set from the fulcrum pin, the longer time it will take before the weight of the sand becomes great enough to over-balance it. By experimenting, one can determine various locations for the weight so that the device will give its alarm after the proper predetermined duration of time.

Contributed by C. M. Wilcox.



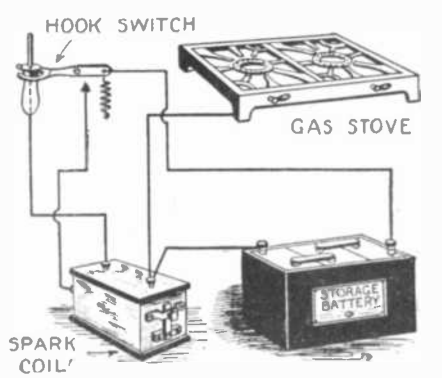
Here is an electric substitute for the hour glass. Sand falling from a funnel into a pan on one side of a beam scale accumulates there and when sufficient has fallen the beam is tipped and rings an alarm.

A Simple Gas Stove Lighter

By Pasqual Stroppa

THIS simple gas stove lighter will prove very useful and will do away with the use of matches. It is easily constructed, with a Ford coil, a few dry cells or a storage battery, a wooden or hard rubber handle and a switch.

The spark coil may be placed under the gas stove or down the cellar where it will be out of the way. Take a wire from the secondary of the spark coil and connect it to a leg of the gas stove. The other end of the secondary is connected to the handle.



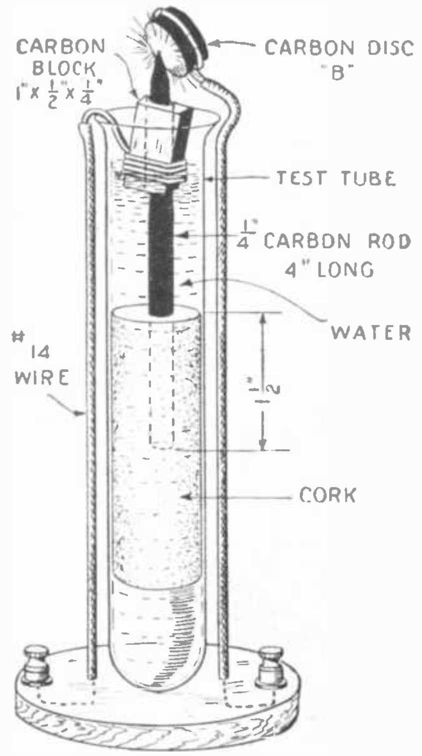
A handy gas-stove lighter can be constructed with the aid of a small spark coil and a storage battery. In lighting the gas is turned on and the electrode is brought near to or touched to the metal burner. A small spark ignites the gas.

The handle can be easily made, or there may be one around the house. Drill a hole through the center of the handle so that a No. 10 wire will fit. The wire must extend out in front of the handle about 1½ inches. The wire which leads to the handle must be of hard rubber covered lamp core.

One end of the primary is connected to the battery, and from battery to the switch and from the switch to the other end of the primary. The switch is a hook switch, the part of a telephone which the receiver hangs on. In this case the handle is hung to such a switch, which should be placed at the spot where it can be easily reached. A spring is placed on the switch as shown. The purpose of this spring is to pull the switch down and make contact and close that part of the circuit, when the handle is taken off. Adjust the spring so that when the handle is on it will be heavy enough to break the circuit.

When the handle is off be sure not to touch the stove, or the point of the wire on the handle. Also when through using hang it up so it will open the circuit.

To light the stove take the handle off the hook-switch and touch the metal burner of the stove after the gas has been turned on a few seconds. The sparking will light the gas.



In this experimental arc-lamp a continuous feed of the lower carbon electrode is insured by the upward pressure of the water on the cork which carries the electrode in question.

Self-feeding Electric Arc Light

By Arthur J. Hessinger, B.S.

THE materials needed are:

One test tube.
One ¼-inch carbon arc pencil, 4 inches long.
One battery carbon.
Two feet No. 14 copper wire.
Two corks.
Wooden base.
Water.

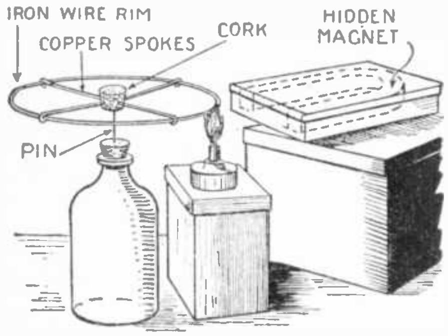
The diagram is self-explanatory. The test tube contains water and the cork float is about three inches long, made up from two 1½-inch corks which are wired together. From the base rise two wires, which are formed into a loop, one for holding the ¼-inch disc cut from the end of a battery carbon, the other for holding the block, cut from the same carbon. This block (A) is held by the bare wire loop and forces the rod (C) against the disc (B). The disc is held in place by forcing it into a loop (E) of wire.

The test tube is nearly filled with water. The carbon rod is inserted in a hole in the upper cork. The tension of the block and disc is carefully adjusted to insure proper connections. The wires are fastened to the base and form the support for the test tube.

To ensure the rigidity of the test tube a round cavity can be drilled in the center of the base.

This arc gives very good results when used on the 110-volt lighting circuit in series with an electric flatiron as a resistance. It is self-feeding.

Mysterious Wheel



This mysterious rotating wheel made of iron and copper wire is actuated by the reaction between the hot and cold portions of the rim and the hidden magnet.

AN interesting and mystifying trick can be performed with the aid of a bottle, having a cork with the point of a pin projecting vertically upward, a hidden magnet, an alcohol lamp or Bunsen burner, and a wire wheel made as follows:

Four copper wires with small hooks at the end are inserted into a cork, forming the spokes of the wheel. Then an iron wire is bent into a circle and held by the hooks. The whole wheel is then balanced on the point of the pin. The lamp is lighted and placed so that the tip of the flame just touches the iron rim.

The whole apparatus is placed as shown in the illustration. After a few seconds the wheel will begin to revolve because the magnet attracts the cooler part of the wheels, which is behind the flame.

Contributed by CARLYLE STEHMAN.

Automatic Window Closing Device

THE object of this device is to enable one to sleep in a cold room with the windows open during cold weather, without waking up in a cold room in the morning.

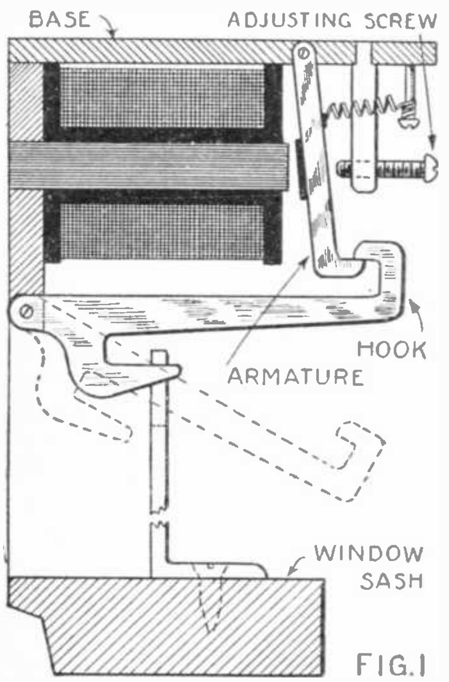


FIG. 1

This electromagnetic release retains the window in open position until the magnet is energized. The armature then releases the hook and the window closes.

Briefly, it consists of an electro-magnetic latch which holds the window open during the night until some predetermined hour. A ring or staple on the top of the window engages the hook of the latch. Early in the morning an alarm clock operates a switch in the latch circuit which releases the hook and allows the window to close.

The operation of this latch is as follows: When a current passes through the magnet winding (Fig. 1), the armature is drawn in toward the magnet, which releases the hook. As the hook falls, the window no longer being supported, closes. It is, of course, necessary to fasten a weight to the window, so that when not supported by the hook it will close without help. When the window is closed, the hook remains in the position shown by the dotted lines in Fig. 1.

As soon as the current ceases to flow through the magnet winding a spring moves the armature back to its original position. When the window is again raised, the top of the ring striking against the hook carries it up with it until the hook automatically locks in position. The window will then remain open until a current again passes through the magnet winding.

The construction is as follows: The yoke piece may be cut out of a piece of iron or cold rolled steel 2½ in. by 1½ in. by ¼ in. Two pole cores of the same material about ⅜ in. are riveted to this yoke piece as shown. The magnet spools may be formed out of brass or some insulating material and wound with No. 20 B. and S. gauge single cotton-covered wire. About five ounces of this wire will be required.

The armature should be cut out of a piece of ⅛ in. sheet iron and bent at the top to

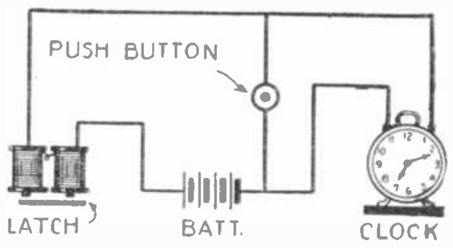


FIG. 2

The diagram illustrates the circuit for the automatic operation of the electromagnetic window closing device. The usual arrangements can be used for closing the circuit with the alarm clock mechanism.

form a bearing and at the bottom to form a support for the hook. The base, the hook and the ring should be cut out of No. 18 sheet brass. A spring must be provided to keep the armature over against the adjusting screw when the magnet is not energized. A suitable spring for this purpose may be formed by winding No. 23 B. & S. gauge phosphor bronze wire on a 3/16 in. rod (in diameter). The spring may be supported on a rod between the two magnet spools. A piece of brass or even pasteboard is attached to the face of the armature to prevent it coming into contact with the pole core ends when the magnet is energized.

For operating this device an ordinary alarm clock is used, the only requirement being that it shall have an alarm winding key which rotates as the alarm rings. Two binding posts are fastened to the back of the clock. One post is in electrical contact with the frame of the clock, while the other is carefully insulated from it. A flat spring is attached to the insulated binding post and bent into such a position that the alarm key will come into contact with it when it rotates. It is not necessary to wind up the alarm completely, but only to give it a fraction of a turn so that in unwinding it will touch the flat spring in passing. But it must pass the spring as it turns, so as to open the circuit again.

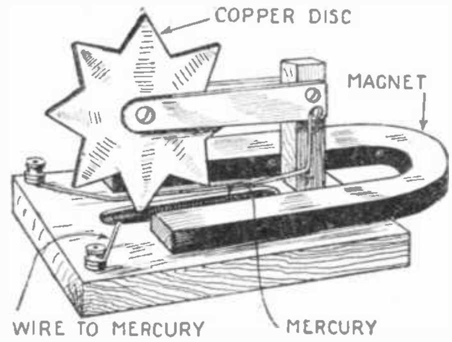
The apparatus should be connected up as shown in Fig. 2.

Contributed by HOWARD S. BABCOCK.

Barlow's Wheel

By HARRY L. ELDER

THIS is a very easy and instructive model to make. Its one disadvantage probably is that it requires a battery capable of discharging at a fairly high rate in order to get good results. If the reader has a good storage cell of 20 to 40 ampere-hours' capacity, or some large bichromate or several Lalande cells, he is urged to make this model. Another essential is a good sized permanent magnet of the horseshoe type. These can be obtained from a junk heap or purchased from a supply house. The writer has managed to get two which apparently came from dismantled "medical" magneto machines. One was in very good condition and cost 20 cents; the other was very weak and lightly



A simple form of the famous Barlow's wheel. Current flowing from the center to the periphery of the wheel reacts with the permanent magnet to produce rotation.

rusted and cost 5 cents. However, it was cleaned up and remagnetized and is a splendid magnet. The sizes of the magnets are as follows:

1⅛ in. × ½ in. section; 8 in. long over-all 1 in. between limbs.

1 in. × ⅜ in. section; 6 in. long over-all. ⅞ in. between limbs.

Such magnets are extremely useful for a variety of experiments, and provided they are carefully treated and put away with a soft iron keeper or armature will give many years' service.

Reference to the illustration will make matters quite clear. The magnet is laid on the baseboard, it being quite unnecessary to fasten it, and in the wood between the poles a small groove is scooped out. This little trough contains a small quantity of mercury, a spoonful being ample. But do not use a spoon as the mercury may attack it. The mercury need not be pure, that used for the amalgamation of zinc plates serving, but it should have a clean surface. Dipping into this mercury is a stout piece of copper wire which leads to one terminal. Above the magnet a thin disk of copper or brass is so arranged that it can move quite freely in its bearings, its edge coming midway between the limbs of the magnet. The disk is about 5 or 6 inches in diameter and its circumference is cut so that it resembles a very exaggerated circular saw or more properly a star wheel.

The bearing is a piece of stout brass wire with pointed ends which work in small holes in the stirrup-shaped frame. It should be soldered in the center hole in the disk and stand out exactly at right angles to its surface. It is best, too, to so arrange the layout that the frame and wheel can be adjusted vertically, as the distance to which the teeth of the wheel dip into the mercury may have to be changed according to the voltage of the applied current. The wheel must work quite freely as the amount of power which is developed is quite small. Adjustment of the magnet, forward or backward, may also be necessary. Provided all is correct, wires from the battery, one to the mercury trough and one to the bearing frame and a starting touch to the disk, should result in steady motion.

Simple Electric Pendulum

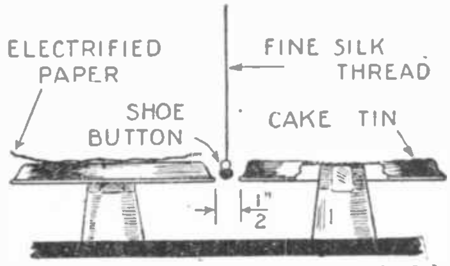
WHILE experimenting with the "simple condenser," shown in January EXPERIMENTER, I made a "simple motor."

Tie a small object to the thread; a shoe button does fine. Use two trays and two tumblers. The diagram is self-explanatory.

When the electrified paper is placed on the tray, the button will vibrate rapidly from tray to tray. The button carries the electric charge from one tray to the other until an equilibrium is established. When the paper is removed, the button will again vibrate.

A piece of tablet paper laid on a varnished surface (table top) and rubbed with a fountain pen or back of a comb will become charged very easily.

Contributed by WM. V. GILPIN.



An addition to the experiment described in the January EXPERIMENTER. A pendulum is kept in oscillation by static discharges.

Unique Electric Motor

By EARLE R. CALEY, B.Sc.

AN electric motor that has neither a field magnet nor a commutator is illustrated here. This motor uses the earth's magnetic field as its field magnet.

As shown in the figure a metal pillar rising from the center of the base has revolving on its top a horizontal wire. Near the end of this horizontal wire are two wires bent inwards in the manner shown and dipping down into a circular groove containing mercury or acidulated water. Wires from the two binding posts on the base lead to the bottom of the brass pillar and to the circular trough.

The principle of operation is as follows: Current from a set of batteries enters the central metal pillar and goes out on the horizontal wire in opposite directions, down the end wires to the liquid in the groove and then back to the batteries. In doing so it forms magnetic poles on the faces of the two loops which are opposite in polarity. These are then always in a state of being alternately attracted or repelled by the magnetic field of the earth and so causing the constant rotation of the wires. The direction of rotation will depend upon the direction of the battery current through the system.

The details for constructing this interesting piece of electrical apparatus are as follows: The base is a piece of three-quarter inch wood twelve inches square. For convenience in making connections and allowing room for the pillar to project a little below, the base should have four blocks of wood, two inches square glued to the corners. A half-inch hole is drilled in the exact center of the baseboard to receive the metal pillar. This central pillar is a six-inch length of half-inch round brass rod or tubing. A conical depression is made upon the upper end of this pillar as a socket for the revolving wires to turn on. This can be readily done by means of a twist drill. If tubing is used, a piece of brass must be soldered across the top to receive the pivot. The groove in the base to contain the mercury or acidulated water is six inches in diameter, one-half inch wide and one-half inch deep. This is most easily cut in, of course, on a lathe, but if this is not available, a satisfactory substitute is one neatly cut by auger, chisel and gouge.

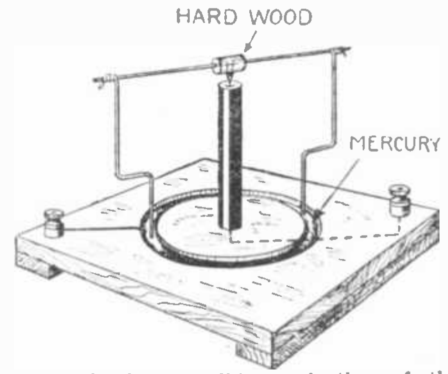
If acidulated water is to be used instead of mercury, this groove should be rendered waterproof by coating it heavily with molten paraffin. After the groove has been cut in, the brass pillar may be permanently fastened in place by wedging it into place and allowing about one-quarter of an inch to project below the base. The two binding posts may now be mounted on the edge of the base and the wire from one led to the projecting pillar and soldered to it. The other wire leads across the base to the trough and runs along the bottom a short distance in order to secure a good connection with the containing liquid. The horizontal and end wires must now be made and mounted in place. It is essential that these wires revolve with the utmost ease and they must be accurately balanced. The method of pivoting this revolving loop is simple. A half-inch cylinder of hard wood is drilled through vertically with a hole of sufficient diameter to hold a piece of No. 12 copper wire.

An eight-inch hole is then drilled in the center of one side to meet the smaller hole. Through the smaller hole is put a ten-inch length of No. 12 copper wire allowing it to project equally on both sides. A pivot made by grinding to a sharp point a three-quarter-inch length of one-eight-inch brass rod is inserted in the other hole fitting tightly against the other wire. Two pieces of No. 12 wire bent in the shape shown are attached to the ends of the horizontal wire. The ends of these two wires should revolve, when the entire revolving loop is in place, evenly about one-quarter of an inch above the bottom of the circular groove.

This loop must be carefully balanced before the device is set in motion to insure its successful operation. For the sake of appearance the base may be stained or varnished in any desired way.

To operate the motor the trough is filled with mercury or with a slightly acid solution of sulphuric acid. Even a solution of common salt will answer the purpose. Wires from a set of batteries are then connected to the binding posts and the experimenter will be rewarded by the rotation of the loop at a fairly good rate. Reversal of the battery current will cause a reversal in the direction of rotation of the motor.

A person seeing this apparatus in rotation for the first time is usually puzzled in trying to account for the reason for its rotation not knowing that the field magnet for this interesting piece of apparatus is really the invisible and yet ever present magnetic field of the earth.



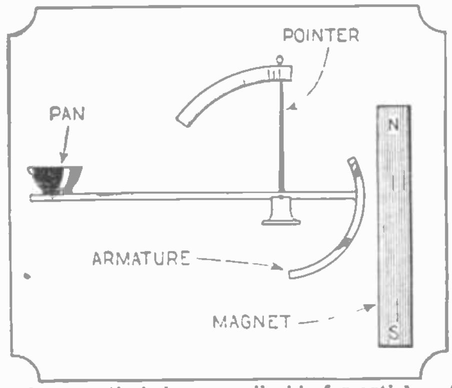
The simplest possible production of the rotating conductor in a magnetic field, following out Faraday's well known work.

Magnetic Weighing Scales

By EMIL J. SCHAU

THE diagram illustrates in simplest form magnetic scales. A piece of brass six inches long, which acts as the lever, has a hole the diameter of a sewing needle drilled through it one inch from one end. The brass should be just heavy enough not to bend under its own weight, and the hole through it should be small enough to allow a drive fit for the needle. The needle acts as the pivot.

Directly above this pivot a pointer is fastened; the tip of the pointer passes over a strip of paper on which two concentric arcs are drawn, so as to give the basis of a calibration. This paper is fastened to uprights forming the supports for the fulcrum. On the short end of the lever an armature of soft sheet iron, bent to form an arc, is fastened in such a manner so that most of it is under the short arm of the lever. A pan is set, freely supported, on three light brass fingers soldered to the other end of the lever, and is to act as a receptacle for the thing to be weighed. A magnet such as one from the magneto of an automobile, is placed so that it exerts an attractive force on the iron armature.



A magnetic balance applicable for articles of light weight such as letters; a really practicable form of scales which anyone can construct.

The magnet is adjusted into a position, where the pointer stands in a true vertical line; a zero is marked on the paper at this point. Then a weight, such as one gram, is placed in the pan, whereupon the pointer moves to a new position, and the value of the weight in the pan is noted on the proper point on the paper. In this manner the entire range of movement of the instrument, about 45°, is calibrated.

The force of the magnet attracting the armature is variable with change of position due to and proportional to the weight of the object placed in the pan; the pointer moves to a position of balance between the weight in the pan and the force exerted on the armature by the magnet. The attractive force of the magnet becomes greater as a greater weight is placed in the pan because a larger part of the armature is brought into the range of the magnet by the movement of the beam.

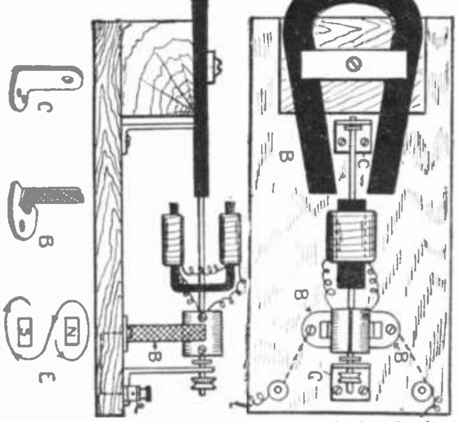
All parts are suitably mounted on a base, and with the exceptions of the steel needle acting as a pivot, the armature and the magnet, the metal parts are of non-magnetic material in order to reduce the possibility of the instrument losing the accuracy of its calibration. The pan is removable so that it may be easily rid of its contents. A clip can take the place of the pan if it is to be used as a letter scale.

This balance is of a nature to suggest variations. The magnet can be placed differently, a polarized armature could be used to give quite different results, and as a suggestion for adjustment, the magnet may be mounted so as to have its distance from the armature varied. We have had occasion before now to illustrate in our columns various uses of magnetized appliances, such as screw-drivers, hammers and the like, and this is quite an interesting example of another application of the magnet to take the place of weights in a scales or balance. We shall hope in an early issue to have some other suggestions for using a magnet, either the permanent magnet or the electromagnet.

Permanent Magnet Electric Motor

By W. E. Edmonds, Jr.

THE electric motor described and illustrated in Fig. 1 is very easy to construct and will run at an approximate speed of 2,000 R.P.M. if carefully made. The principle on which this motor acts is: Like magnetic poles repel, unlike poles attract. The commutator always changes the current at such a time that the action between the permanent magnet and electromagnet keeps the electromagnet in motion.



This electric motor capable of developing some useful power is designed after the form of one of the earliest electrical motors. Its field is a permanent horseshoe magnet. The winding of the armature coils is shown diagramatically at (E).

The permanent steel field magnet first demands our attention. This magnet is obtainable in many of the 5- and 10-cent stores and is 4½ or 5 inches long with limbs ½x3/16 of an inch, with a distance of ½ inch between limbs.

The electromagnet armature is made from a piece of soft strap iron 4 inches long by ½ inch wide and ⅛ inch thick and is bent horseshoe-shape, the strip first being heated to redness. The legs of the magnet are about 1½ inches long. A hole is drilled centrally in this magnet and a 4-inch shaft made from a perfectly straight piece of No. 14 copper wire is soldered truly in this hole in the magnet which should be well balanced. This shaft should protrude about 2 inches on the commutator end (a). A small collar or washer (b) is soldered on the front end of the shaft. Two bearings (c) are now made from brass 1/16 inch thick. Each bearing is made from brass 2½ inches long by ½ inch wide, about ½ inch is bent at right angles to the rest and the end of each long arm is neatly rounded off, as illustrated in detail. Two holes for screws are drilled and countersunk in each of the short arms, the commutator (a) consists of a short length of brass tubing ⅝ inch in diameter by ⅝ inch long. This tube is forced onto a circular piece of hardwood, before which the interior of the tube is given a coat of shellac. This circular disc of wood is centrally drilled to accommodate the shaft. Four small round-headed brass screws are screwed into the wood, two at each end of the diameter. Two saw cuts are now made on each side of the diameter at right angles to the screws. These saw cuts must be clear through the brass shell and a short distance into the wooden plug. The commutator is now forced on to the shaft so as to clear the magnet by about ⅛ inch. It is twisted so that the saw cuts are at the top and bottom when the magnet limbs are at the top and bottom.

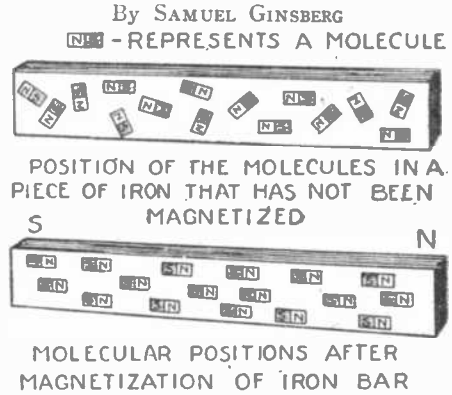
The armature magnet limbs are now wound with wire. Before winding, each limb is covered with thin oiled paper so that no bare iron is exposed. We now commence winding by securing an end of the wire under one of the screw heads on the commutator and winding each limb with six layers of No. 24 D.C.C. magnet wire, winding each turn close to the last, with six layers, or about 100 feet of wire on each arm. When crossing over to the second limb wind the wire the reverse direction, as shown in (e). When both limbs are wound with the same number of turns, the free end is securely fastened under the screw head on the other half of the commutator.

The rear bearing is now mounted on the armature shaft. A small washer is placed on the shaft between the bearing and the commutator.

The base for the motor is made from a piece of well-seasoned wood about 6 inches long by 3 inches wide and ½ inch thick. This is planed and sandpapered up and then given a coat of shellac. The saddle for the field magnet is then constructed, 1 15/16 inch thick and is fastened in place with small screws through the base. The permanent magnet is placed upon this, as illustrated, and the saddle is screwed down on its top. The front bearing is securely fastened to the base so that only a small amount of clearance is given between the field magnet and armature in place. The rear bearing is then secured to the base, only allowing a small amount of end play to the armature and shaft. Two binding posts are fastened to the rear end of the base which connect with the brushes which are made up from brass gauze and a small piece of 1/16 inch sheet brass, as shown in (f). There are two brushes, one on each side of the commutator. If desired, a small pulley may be secured to the armature shaft.

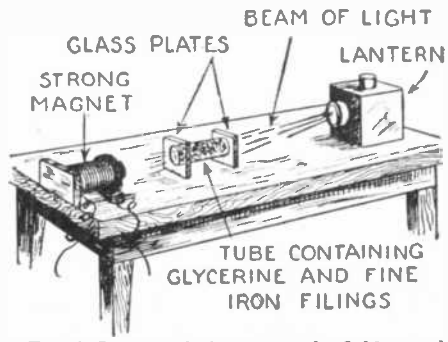
Experimental Proof That Magnetism Is a Molecular Property

By Samuel Ginsberg



According to one magnetic theory each molecule is a small magnet. When a bar of iron is unmagnetized, these small unit magnets are disposed in a haphazard manner. When, however, the body is magnetized, they assume a position with all north poles facing in one direction. These two conditions are illustrated diagramatically above.

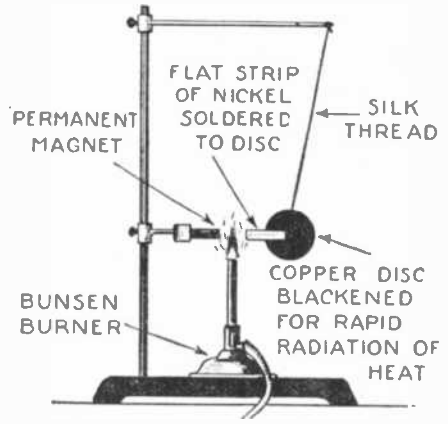
BEFORE we can describe the experiments we must state the physicists' explanation of magnetism.



The influence of the magnetic field can be effectively demonstrated by placing fine iron filings in a tube containing glycerin, the axis of the tube being on line with a powerful electromagnet. When the magnet is energized, the filings will arrange themselves in parallel rows.

Magnetism is now considered to be caused by molecular action. If a magnet be broken into many pieces each piece becomes a magnet in itself with a north and south pole. This is true, however far the subdivision may go. Physicists have come to the conclusion, therefore, that each molecule is a magnet with a north and south pole.

In an unmagnetized piece of iron the molecules are entirely out of alignment. Since



That magnetism is a molecular phenomena is demonstrated by the apparatus above. A nickel strip when cooled is attracted by a permanent magnet. When heated, however, the nickel loses all magnetism and is released by the magnet.

each molecule is only a very minute magnet no magnetic effect is produced.

Magnetization of an iron bar, however, brings these molecules into magnetic alignment, *i. e.*, all like poles are turned in the same direction. (See illustration.) Magnetism is, therefore, the resultant effect of all these molecular magnets.

If a magnet is hammered severely or twisted it will lose part of its magnetism. This is because some of the molecules are moved from their magnetic alignment.

Steel is harder to magnetize than soft iron because the former's molecules are more compact and cause greater internal friction. Steel, however, when it is once magnetized, will retain its magnetism for the same reasons. The following experiment is even more interesting and convincing:

If a sealed tube containing iron filings is placed in a strong magnetic field produced by an electromagnet, the tube will become a magnet. If the tube is now shaken vigorously, it will lose its magnetic properties.

Assuming that the iron filings contained in the tube represent iron molecules, the loss of magnetism due to the shaking was caused by the movement of the iron molecules out of magnetic alignment.

When the magnetic field is no longer present no light from the lantern will pass through the glass tube containing the glycerine and iron filings, which behave just as the iron molecules would. But when a magnetic field is set up, the iron particles arrange themselves with their axes parallel to the field and permit some of the light to pass through.

If iron is heated to a red heat it can no longer be magnetized, nor can it be attracted by a magnet. This is, no doubt, due to the rapid vibration of the molecules at this temperature; they cannot be kept in magnetic alignment.

An interesting experiment illustrates this point.

Nickel has the same magnetic properties as iron; it is, therefore, attracted and held in place by the permanent magnet. When the nickel is heated with the Bunsen burner it loses its magnetic properties and the disc swings backward. The black copper disc radiates heat quickly and the flat strip of nickel soon cools and is again attracted by the permanent magnet. This process of swinging back and forth will continue so long as heat is applied.

Awards in the $50 Special Prize Contest
For Junior Electricians and Electrical Experimenters

First Prize, $25	Second Prize, $15	Third Prize, $10
Roscoe Betts, Box 4, Arcadia, Nebraska	Arthur Lauchner, 624 Second Avenue, S.W., Great Falls, Montana	Author Unknown

First Prize
Improved A. C. Buzzer

By Roscoe Betts

A. C. buzzers described heretofore in The Experimenter or Practical Electrics have employed electro-magnets, which merely pulled the armature in one direction, letting it return by its own elasticity.

However, for an A. C. buzzer which has the maximum sound, the builder will find the instrument to be described very serviceable.

Procure a permanent horseshoe magnet and wire to each of its poles a right angled iron strip as shown in Fig. 1. These strips are wired on, because if riveted or soldered the heat used would tend to destroy the magnetism of the permanent magnet.

These strips form cores for the coils which are next wound. The method of

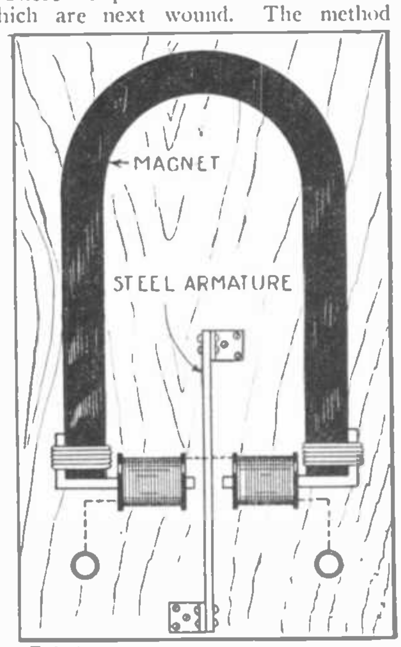


FIG. 1

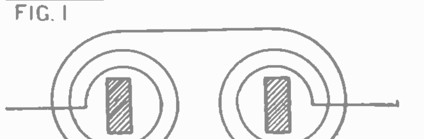


FIG. 2

This is a type of polarized alternating current buzzer. The successive alternations of the current weaken one pole and strengthen the other alternately, the armature being attracted to the stronger pole.

winding is shown in Fig. 2. If the instrument is to be connected directly into a 110-volt circuit, the coils must be wound with a great quantity of fine wire, about 28 or 30 B & S gauge.

The armature, which may be made from an old hack-saw blade or other steel band, is riveted or bolted to two angle pieces which are fastened to the baseboard.

If the coils are wound correctly, one phase of the cycle will increase the magnetism at one pole and neutralize the magnetism at the other, and the other phase will do the reverse in regard to the poles.

It will be found that a strong vibration effect and good volume of sound are produced.

$50 IN PRIZES

A special prize contest for Junior Electricians and Electrical Experimenters will be held each month. There will be three monthly prizes as follows:

First Prize	$25.00 in gold
Second Prize	$15.00 in gold
Third Prize	$10.00 in gold
Total	$50.00 in gold

This department desires particularly to publish new and original ideas on how to make things electrical, new electrical wrinkles and ideas that are of benefit to the user of electricity, be he a householder, business man, or in a factory.

There are dozens of valuable little stunts and ideas that we young men run across every month, and we mean to publish these for the benefit of all electrical experimenters.

This prize contest is open to everyone. All prizes will be paid upon publication. If two contestants sumbit the same idea, both will receive the same prize.

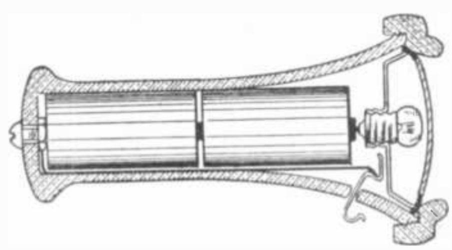
Address, *Editor, Electrical Wrinkle Contest*, in care of this publication. Contest closes on the 15th of each month of issue.

Second Prize
Telephone Case Flashlight

By Arthur Lauchner

A VERY interesting little flashlight is shown in the accompanying illustration which speaks for itself.

An ordinary telephone case contains a flashlight battery and at the diaphragm end the flashlight bulb, with lens or convex glass



This very unusual flashligh is ingeniously constructed out of a discarded Bell telephone receiver case and a few odd brass parts.

or other protection as desired in front of it, is supported by a metal diaphragm.

The center connection of the lamp rests upon the central terminal of the battery, and the circuit is completed through a thumb switch shown on the upper right hand of the section. This makes an exceedingly neat flashlight, adapted especially for cylindrical cells.

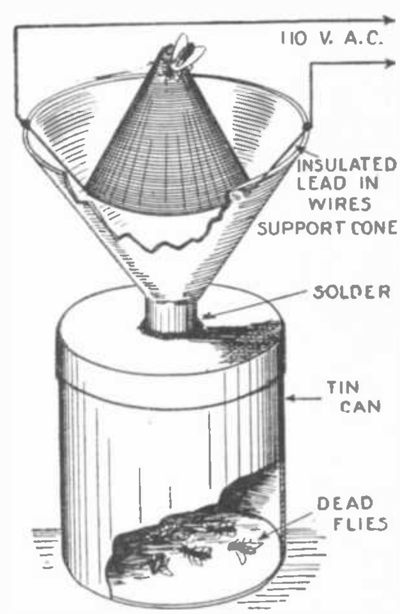
This will remind our readers of a contest in Practical Electrics for devices constructed utilizing telephone cases. The one we illustrate above is a very simple and interesting one.

Third Prize
The Fly's Electric Chair

THIS is a method of electrocuting our common enemy, the fly.

First secure a good sized funnel, a large baking powder can or the like, and the upper third of a cardboard cone such as storekeeper's cord is wound on.

After giving the cone about two coats of shellac it is wound with two pieces of wire, preferably No. 18 bell wire, which has a fairly thick waxed insulation. The two wires are wound parallel up the cone, which should still be sticky from the shellac. The two ends of the wires are put through two neat holes in the top of the cone. No electrical contact should exist in the coil lest it



Human malice is here set against the innocent fly who when he alights on the conical coil of bared wire becomes electrocuted by bridging across a potential of 110 volts. An appropriate morgue is provided in the form of a tin can.

blow the fuse when connected to the electric light circuit.

As far as the winding of the cone is concerned the coil is now finished, but there must be an electrical contact for the fly. This contact is made by carefully scraping the insulation from the exposed surface of the wire on the cone, but leaving it untouched between the layers of wire. The coil is now shellacked and carefully scraped again, after which it is coated with molasses. After the molasses has hardened, it, too, is scraped from the bare part of the wire. The smell of the molasses will tempt the fly to his doom.

By using the two lead-in wires as supports, the coil is suspended inside of the funnel, although not snugly. The narrow end of the funnel is soldered to a hole in the lid of the can and the death cage is assembled as shown in diagram.

What Our Readers Think

The Nature of Matter

Editor, THE EXPERIMENTER:

Having read the article "Some Speculations on Ether by Philomath" in THE EXPERIMENTER, I am encouraged to send you the following notes:

I have no patience with the purely mathematical theories such as Einstein's. Mathematical treatment is an invaluable tool but it must be used with much discretion. If we lean on it too heavily, we go far astray. Mathematics are simply logical reasoning from premises and its weakness lies in the fact that the premises are never complete. When the real truth about the nature of matter and energy is known, it will not agree with our present mathematical formulas, but it will be possible to formulate mathematical theories that will agree with the facts,—because then we will know all the premises. This leads to the idea that it is a mistake to limit ourselves to hypotheses that agree with the formulas that the masters have worked out. At any rate it will be a pleasant mental exercise to forget some of old theories and make a new start.

Getting back to first principles, we find a world of diverse yet related kinds of matter that may be and usually is divided into many small particles. All of this matter is more or less in motion, both as to the aggregate masses and as to the individual particles. The effects of these motions we attribute to energy, and we see no evidence that energy is anything aside from motion. We note a general tendency for this energy to dissipate into space and are lead to the conclusion that if it were not being constantly supplied from some source outside our world, all motion would soon cease. We see evidence of forces that seem to draw objects together as though there were attraction between them. We find much evidence for the existence of another substance more subtle than common matter and not subject to the same laws, yet involved intimately with the laws that govern common matter. We call this substance electricity.

The idea that objects may attract one another is a mistake, since the effects may be explained more simply by the idea that when two bodies come together, they are pushed. If we suppose that all known space is filled with radiant energy acting in straight lines equally in all directions, we have a cause for an effect like the force of gravity. If two bodies are placed in this medium of rays, they will cast shadows on one another and the effect will be an unbalanced pressure tending to push them together. This radiant energy may be transmitted in two ways, by wave motion in a medium and by the motion of corpuscles moving along straight lines by regular surges in otherwise empty space. We find evidence that both methods are used. The earth (and all other bodies—earth conditions predominating for us) is surrounded by a layer of electric fluid, denser at the surface and thinning out rapidly upward. Near the earth it transmits radiant energy as wave motion, but out where it is thinned down to almost zero density, its particles are thrown off and travel through space as corpuscles. These particles are not electrons but smaller particles than electrons that may be measured by Planck's constant.

All of the known effects having to do with matter and energy are functions of size (magnitude) and motion. Many effects are related more particularly to relative size and relative motion.

The size of a particle determines its normal velocity—the velocity at which it "tunes in." Thus the above corpuscles move naturally at the velocity of light. These corpuscles are so plentiful and so full of motion that they are constantly striking one another. The kinetic theory comes in here (perhaps only here) and by the constant bombardment electrons are constrained to move about, to revolve on their axes, and to revolve about centers. Thus atoms are made.

The importance of relativity in connection with size and motion cannot be overestimated. A body in motion has a different character from the same body at rest. For instance a chain spun about its longitudinal axis becomes a rigid rod or, if its ends are brought together, a rigid vortex ring. A ball revolved in a circle at high speed becomes a solid ring. We may suppose that an electron is composed of a dense mass of corpuscles. This mass spins on its axis at high speed. It is surrounded (like the earth) by an atmosphere of electricity. It is very dense—casts a heavy radiant energy shadow—and its electric atmosphere is consequently very thick. This atmosphere partakes more or less of the motion of rotation of the electron and thus causes electrons to repel one another at some distance.

We said before that the size of a particle determines its normal velocity. We might reverse this idea and say that the size of any particle built up of smaller ones is a resonance effect. So also is chemical affinity. In short—everything that is stable is in tune with its environment.

Boise, Idaho. JOHN B. PLATTS.

(Your interpretation of what is usually called gravitational attraction is very interesting. It is open to some objection which, however, we cannot elaborate here. We are very glad to note that our readers take interest in the theoretical aspects of science. While our chief interest is experimental, theoretical speculation throws great light on experimental science. Indeed, few great experiments were carried out without some preliminary theory.—EDITOR.)

These columns are reserved for your opinions. Don't hesitate to communicate to us your comments and suggestions regarding THE EXPERIMENTER.

—EDITOR.

Science and Analogy

Editor, THE EXPERIMENTER:

I read the articles in the March, 1925, issue of THE EXPERIMENTER on the question: "Is Life a Form of Electricity?" with great interest. But I must confess that I don't see any value in drawing such analogies as Professor Berget points out between plant structure and electromagnet fields. What if there is a curious resemblance between them? Were we to let our imaginations roam freely we could discover hundreds of such unsuspected analogies in other departments, but we would be at fault to conclude or even to suspect therefrom that there is any identity between the various phenomena. So with Professor Berget's suggestions. Because under very special circumstances he has noted certain similarities between fibres of plants and diagrams of electric fields he is far from justified in suggesting that there is any fundamental similarity between the causes of the electric field and the plant structure.

THOMAS SHAFTESBURY.

Hartford, Conn.

(If you mean by your comment that such analogy is no demonstration of actual identity between the phenomena considered we quite agree with you. However, you must observe that such analogies have not only very valuable possibilities in suggesting relations between supposedly isolated phenomena, but have actually served in good stead in the case of many great research workers. We might mention as one illustrious instance, the case of Faraday who long before he demonstrated the actual relation between light and electromagnetism, wrote in his notebook, "I have long held an opinion, almost amounting to certainty, in common I believe with many other lovers of natural knowledge, that the various forms under which the forces of matter are made manifest have one common origin, or in other words, are so directly related and mutually dependent that they are convertible." To this mere opinion Faraday adhered with such tenacity that no discouragement could shake his faith in it and he was finally rewarded by his famous discovery of the inter-relation between light and magnetism. —EDITOR).

Pure and Applied Science

Editor, THE EXPERIMENTER:

I have been following your series of Historic Experiments very carefully and was struck by the fact that the experiments which you discuss in those pages are almost without exception of such a nature as to have no practical application. I think that you are omitting that very important series of experiments which must at one time have been performed by people who were more practical and more inventive than the research workers you discuss in this series. Such omission, it seems to me, is an important defect in an otherwise very interesting presentation of the history of experimental science.

Baltimore, Md. HENRY D. HARRISON.

(The opinions you expressed in your letter are quite common among people whose acquaintance with science is limited to its more concrete and tangible forms, that is, the inventions. These always appeal to the layman because their utility and importance are obvious. But we wish to call your attention to the fact that most, if not all, inventions are based upon principles which are in themselves abstract and of little immediate utility. The discovery of these principles entailed long series of research in experiments which seemingly dealt with problems of purely academic, that is, "impractical" interest. This research was carried on by men who were not directly interested in practical results but who were motivated rather by an intense curiosity. A desire to discover truth rather than to obtain practical results, was the urge to carry on this work.

An invention is usually, even in its broadest form, highly specialized. Such discoveries as we have discussed in our Historic Experiments, on the other hand, have been and are essentially basic, establishing not a new application of some old principle but new revolutionizing principles which in turn became the cradle of thousands of inventions.

We might mention as an example of the outcome of such research, the so-caled Edison effect. Long after Edison discovered the conductivity of a vacuum in which a hot filament is located, this principle was studied by scientists and their apparatus was considered largely as academic toys. Yet, from these seemingly impractical experiments the latest marvel of radio, the vacuum tube, resulted. —EDITOR.)

The Experimental Method

Editor, THE EXPERIMENTER:

Since some time back I have been trying to discover for myself, what the essence of experimental science is. I have been dabbling in experiments of all sorts ever since I was seven years old. I have done a good deal of original work, but I can't yet explain satisfactorily to myself just what constitutes the experimental method. Could you not give us a brief account of the methods of experimental science and perhaps a little of its development? I am sure there are many other experimenters who would also like to have your opinion on this matter.

Madison, Wisconsin. WILLIAM BRANDT.

(The questions concerning which you inquire are the subject rather of philosophic than scientific inquiry, but we might in reply venture a few remarks on the subject.

Despite popular belief, science is not a child of modern civilization. It was fostered by ancient Greece, and in the hands of the philosopher Thales it reached considerable significance. Others followed him, concerning themselves with natural phenomena and enriching the libraries with profuse speculations. In Alexandria gathered large numbers of the world's ablest minds to pursue the aims of science and yet they made but little progress in their field. Contrasting the rapid advances of our own time with the snail-like development of Greek science, we are led to believe that this difference is due not merely to the more extensive information in our possession. The superiority of the modern over the ancient scientist is radical in nature, resting not on a difference in information but on a difference in method.

The method of science is distinct from its subject matter. It is a habit of mind, acquired like all habits, through persistent application. It is primarily a device to facilitate the pursuit for truth. It is of use only in so far as it makes this pursuit more rigorous, more reliable and more beautiful.

The method of the Greeks was beautiful, but it was neither rigorous nor reliable. They studied things in themselves. They dealt with ideas. Their science was dialectic. They were content with abstractions, and swept away by beauty of their ideal systems, they were led to believe in corresponding concretions in reality. This spirit persisted. Only here and there we find a mind—far in advance of the times—vainly groping for the intellectual revolutions that were destined to come later. So we find the old Hebrew prophet, Job, saying: "Speak to the earth and it shall teach thee." That is what the ancients failed to do. That is the essence of the modern spirit. That is experimentation.

Gradually, this new method—the experimental method—insinuated itself into modern thought. First, Roger Bacon, that medieval pioneer of science, covering most of his valuable contributions under ecclesiastical subterfuge and cipher, advocated the necessity for experiment in any investigation. He, himself, was one of the first to submit theories of natural phenomena to experiment. After him came a long line of bold experimenters, who, undaunted by clerical censure and persecution persisted in bringing to bear upon worn-out notions the illumination of experiment. What courage, what love for investigation characterized these men! Copernicus, an obscure priest, who spent a life-time in collecting data to demonstrate his new theory of the solar system; Kepler in midst of poverty and illness, succeeded in furthering this theory, and Galileo carried on his revolutionary experiments. These great pioneers of science, like fervent evangelists, preached the new faith in experimental investigation before which scholastic authority was bound to succumb.

These are the traditions sustaining the modern experimenter. He stands on the foundations of a brilliant past and faces a promising future. He stands, thanks to these earlier investigators, on a higher level than they did and commands a larger field. Science through extended diversity is achieving a higher unity, a co-ordination of its elements, and more and more it is enriching man's imaginative outlook. The success of this movement is a tribute to the vast army of keen, observant, and appreciative experimenters.—EDITOR.)

A Pleasant Appreciation

Editor, THE EXPERIMENTER:

I have taken the last two issues of the EXPERIMENTER and like it so well that I thought I would write and tell you. Well, I like the EXPERIMENTER so well that I wouldn't swap the two issues I have now for all the other magazines in the house.

I am sending a little contribution along with this letter, and I am wishing you and the EXPERIMENTER a great success.

Yours truly,

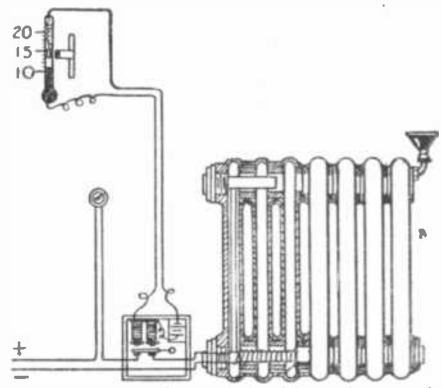
GEO. E. BARBOUR.

Penacook, N. H.

(It is very gratifying to note that our readers find so much to their liking in the new EXPERIMENTER. We have certainly done much to recreate our former ELECTRICAL EXPERIMENTER and even improve upon it considerably. The EXPERIMENTER, we feel, has a more serious and yet more lively scientific interest.—EDITOR.)

Latest Electrical Patents

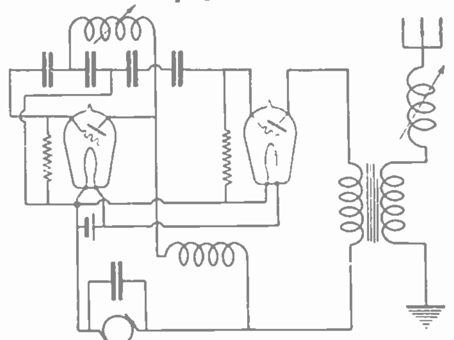
Electric Hot Water Radiator



An electric heating unit in this radiator maintains the temperature of the water at 85 degrees. A thermostatic control is employed to regulate the flow of current. The invention is very ingenious and combines the advantages of a hot water heating system with few of its drawbacks.

Patent No. 1,524,430 issued to O. Graver, Lucerne, Switzerland.

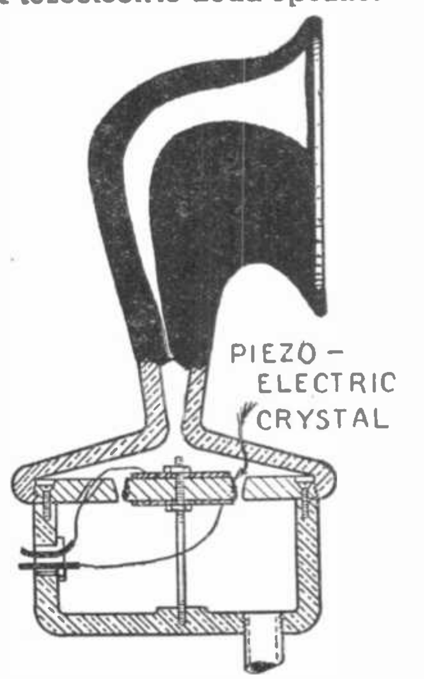
Non-Overload Transmission System



The inventor of this circuit claims that the usual danger of overloading the tube when the radiating system is tuned to the oscillator, is eliminated.

Patent No. 1,526,311 issued to M. C. Batsel, Wilkinsburg, Pa.

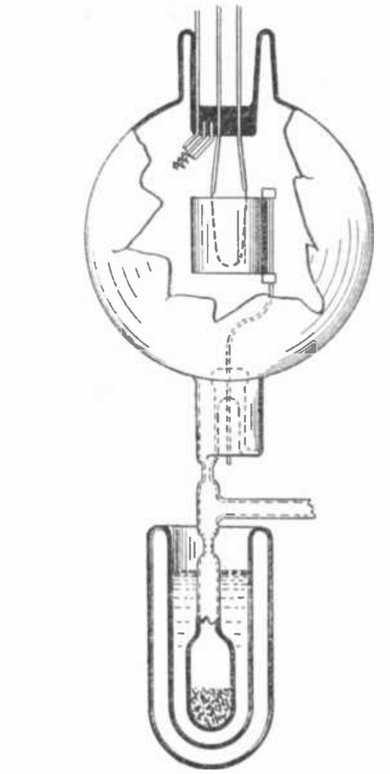
Piezoelectric Loud Speaker



This loud speaker has a continuous stream of air passing through small orifices whose size is controlled by the piezoelectric crystals in accord with the variations in the electric current.

Patent No. 1,526,319 issued to L. W. Chubb, Edgewood, Pa.

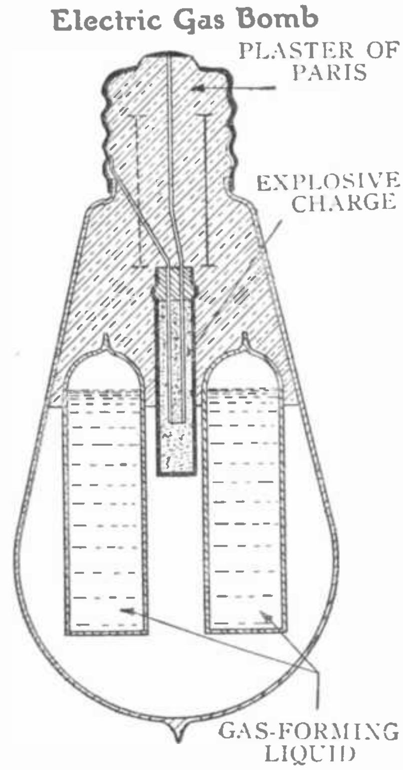
Improved Power Tube



Dr. Langmuir in this invention provides a receptacle carrying napthaline or other carbonaceous material and connected to the main tube. It is claimed that the vapors from this substance maintain the thoriated filament in a non-oxidized state. The napthaline receptacle is surrounded by a freezing mixture.

Patent No. 1,529,597 issued to I. Langmuir, Schenectady, N. Y.

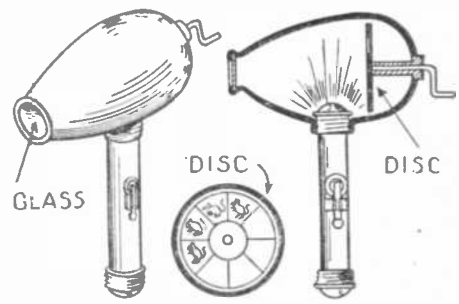
Electric Gas Bomb



This device shaped, like the usual incandescent bulb, is exploded when a button conveniently placed is pressed. In case of bank burglary, a clerk presses a button, setting off the bomb. This distracts the attention of the burglar and gives an opportunity to the clerk to duck behind the counter and apply his gas mask while the burglar is overcome by the incapacitating gas.

Patent No. 1,526,351 issued to R. D. Lawrence, Bellevue, Pa.

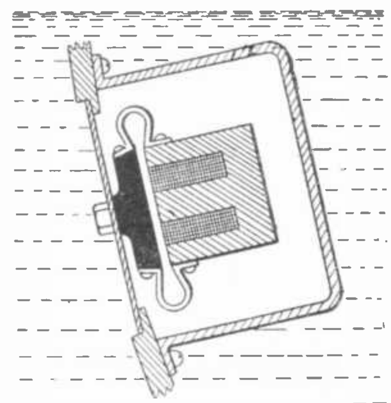
Illuminated Toy



Pictures arranged on a hand-rotated disc illuminated by a pocket flashlight make this a very entertaining and novel toy. The pictures are observed through a small window. The toy is detachable from the flashlight.

Patent No. 1,516,718 issued to C. I. Dailey, Jeffersonville, Ind.

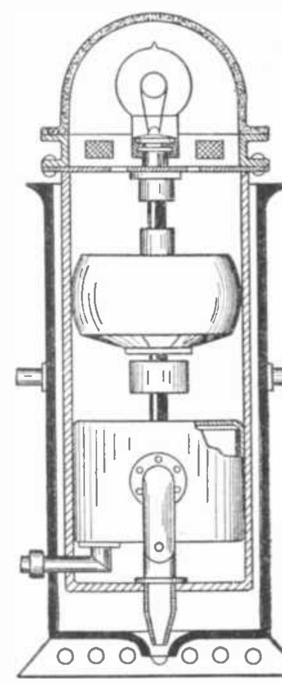
Submarine Signaling



This is another form of vibrating apparatus producing sound waves under water for sounding and signaling purposes. The device is a modified form of telephone receiver.

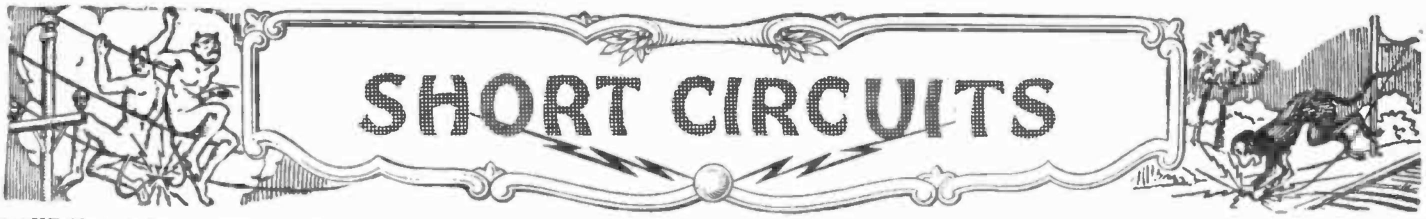
Patent No. 1,526,414 issued to A. du Bois-Raymond, Plon, Germany.

Portable Lighting Plant



This very compact lighting outfit contains a small hydraulic turbine directly connected to the shaft of a small electric generator which supplies power to the incandescent bulb. The turbine is connected to a faucet.

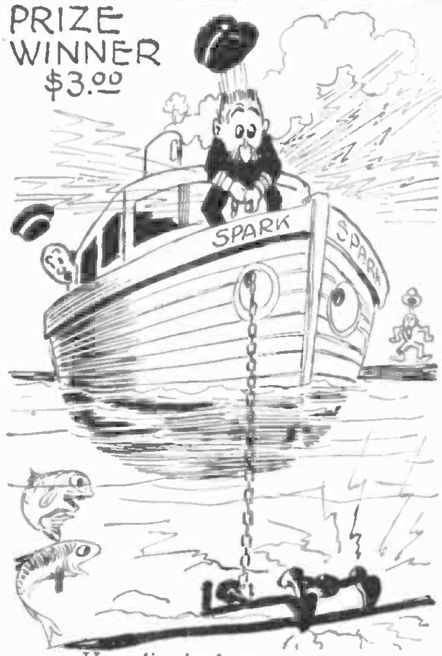
Patent No. 1,528,754 issued to M. Bresson, Douai, France.



SHORT CIRCUITS

THE idea of this department is to present to the layman the dangers of the electrical current in a manner that can be understood by everyone, and that will be instructive too. There is a monthly prize of $3.00 for the best idea on "short-circuits." Look at the illustration and then send us your own particular "Short-Circuit." It is understood that the idea must be possible or probable. If it shows something that occurs as a regular thing, such an idea will have a good chance to win the prize. It is not necessary to make an elaborate sketch, or to write the verses. We will attend to that. Now, let's see what you can do!

Lo, under this sod
Lies Miss Lillian Leater.
No more she'll switch on the light
While sitting on a heater.
—Marion Clemtz.



Here lie the bones
Of Captain McGuire.
He dropped his anchor
On a high tension wire.
—John Parker.

This stone marks the grave
Of Dorothea Pulp.
She darned damp stockings
On a lighted electric bulb.
—Clair Hunt.

Beneath this green
Lies William Myers.
As a lineman he used
Uninsulated pliers.
—Jack Fortini.

Expert Test Engineer Meets Instant Death By Electrocution at Schenectady Plant—Was Prominent While at College Here.

Schenectady, May 1.—Allen Park Toms, 23, an expert test engineer with the General Electric Company of this city, was electrocuted here this morning when he came in contact with the charged part of a generator and 1,500 volts of electricity passed through his body.

Toms was operating a generator, and for some reason not known by plant officials as yet, stepped upon it when it was running. When he touched the live part of the frame, the current was automatically shut off. Other employes went to his assistance and pulmotors were used for two hours without success.

GIRL ELECTRICUTED BATHROOM

CLEVELAND, Nov. 30.—Funeral services will be held Saturday for Mary O'Hare, 12, who was electricuted while taking a bath at the home of her parents, Mr. and Mrs. J. F. O'Hare, Lakewood, on Thursday.

Unable to force the door of the bathroom in which the girl had locked herself, the mother, who was awakened by a low cry, called the Lakewood fire department.

Firemen broke thru the window from ladders and found the girl dead on the floor with her body touching a small electric heater.

Here sweetly lies
One Ignatius Phall.
He drove a ten penny nail
Through a wire in the wall.
—George Newman.

In connection with our Short Circuit Contest, please note that these Short Circuits started in our November, 1921, issue and have run ever since. Naturally, during this time, all of the simple ones have appeared, and we do not wish to duplicate suggestions of actual happenings or short circuits. Every month we receive hundreds of the following suggestions, which we must disregard, because they have already appeared in print previously. Man or woman in bath tub being shocked by touching electric light fixture or electric heater. Boy flying kite, using metallic wire as a string, latter touching an electric line. People operating a radio outfit during a thunderstorm. Stringing an aerial, the latter falling on lighting main. Picking up a live trolley wire. Making contact with a third rail. Woman operating a vacuum cleaner while standing on floor heating register, etc. All obvious short circuits of this kind should not be submitted, as they stand little chance of being published.

THIS department is conducted for the benefit of everyone interested in electricity in all its phases. We are glad to answer questions for the benefit of all, but necessarily can only publish such matter as interests the majority of readers.

1. Not more than three questions can be answered for each correspondent.
2. Write on only one side of the paper; all matter should be typewritten, or else written in ink. No attention can be paid to penciled letters.
4. This department does not answer questions by mail free of charge. The Editor will, however, be glad to answer special questions at the rate of 25 cents for each. On questions entailing research work, intricate calculations, patent research work, etc., a special charge will be made. Correspondents will be informed as to such charge.

Kindly oblige us by making your letter as short as possible.

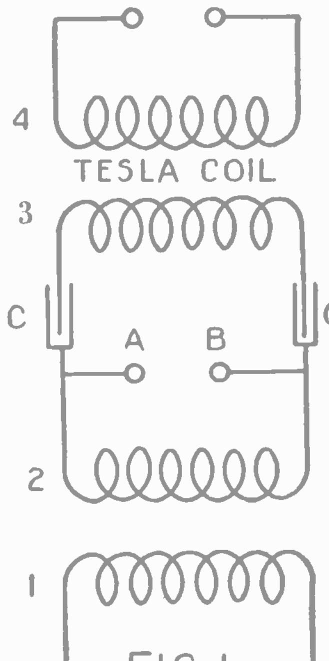


FIG. 1

The diagram shows one type of connection for the Tesla coil. (1, 2) is a step-up transformer. C and C_1 are condensers of equal capacity.

Selectivity

(517) Ralph Gans, Butter, Mont., asks:

Q. 1. I have always been under the impression that a large size wire on coils will increase the selectivity of a set. Is this true?

A. 1. Yes, but a large size wire is not necessary in a radio receiving set if viewed from the point of selectivity. However, there are other factors to be considered than selectivity, when considering the size of the wire. Usually, for the average inductance, No. 22 or No. 24 D.C.C. will keep resistance at a minimum, providing that the form losses are also at a minimum.

Q. 2. Are low loss condensers necessary in a set? I have heard so much, both pro and con, that I am puzzled as to what this "low loss" talk is all about.

A. 2. Obviously, losses in a receiving set should be kept low. If one condenser presents a lower loss factor than another, it is a better condenser. Because a condenser happens to be termed "low loss" does not necessarily make it so. It has been found many times under laboratory test, that the condensers having bakelite end plates are actually of a lower resistance and have a lower loss than those with the aluminum or cast iron end plates. Losses lie wholly in the mechanical details of the condenser, considering, of course, that all end plate insulation is of the highest quality and brought to a minimum, by cutting out the excess insulation.

Tesla Coil

(518) Lionel Stevens, Sidney, Australia, inquires:

Q. 1. What is the principle of operation of the so-called Tesla coil?

A. 1. The principle upon which the Tesla coil is based consists in introducing high frequency currents from the discharge of the condenser into the winding of a special transformer; the condenser being charged by means of an induction coil or by a transformer operating on low frequency and high tension. The apparatus may be connected in two ways, both pointed out by Tesla in 1891. In the first arrangement, Fig. 1, the circuits (1) and (2) represent either an induction coil or a commercial high voltage transformer. The coil charges two condensers, C and C_1, which are connected to the primary (3) of a high frequency transformer. A spark gap (AB) is connected to the terminals of the circuit (2).

As the current in the secondary (2) increases, the condensers C and C_1 are charged until they reach a potential sufficient to discharge over the gap (AB). This spark causes a sudden variation in the potential of the condensers and a current of extremely high frequency is set up in the primary (3). This high frequency current is a result of the oscillatory nature of the discharge across the gap (AB). Currents of the same high frequency but very much higher voltage are set up in the secondary (4) of the Tesla coil. The operation of the second type of Tesla circuit shown in Fig. 2 is similar to that outlined above.

Caffeine Solvents

(519) E. Everett, Sutton West, Ontario, Canada, asks:

Q. 1. Are there any organic solvents of caffeine, guanine and uric acid, and how are caffeine and uric acid obtained from natural sources?

A. 1. Guanine is soluble in acids and alkalis, almost insoluble in water and alcohol. Caffeine is soluble in 75 parts of water at 15 degrees C. and is less soluble in alcohol and ether. Uric acid is barely soluble in water, is soluble in concentrated sulphuric acid and in alkaline hydroxides. The most soluble of the mono-salts of uric acid is mono-lithium-urate; soluble in 60 parts of water at 50 degrees C. Lysidine chloride is soluble in 6 parts of water and hyperazine is soluble in 50 parts of water.

To prepare uric acid from guano boil with an alkaline hydroxide until no more ammoniacal gas comes off and precipitate with a mineral acid, filter, wash and dry.

To prepare caffeine, extract tea with hot water, precipitate tannin and albuminoid with basic lead acetate, filter, precipitate the lead in the filtrate with sulphuric acid, and extract with chloroform; best in a regular extracting apparatus; evaporate to get crystals

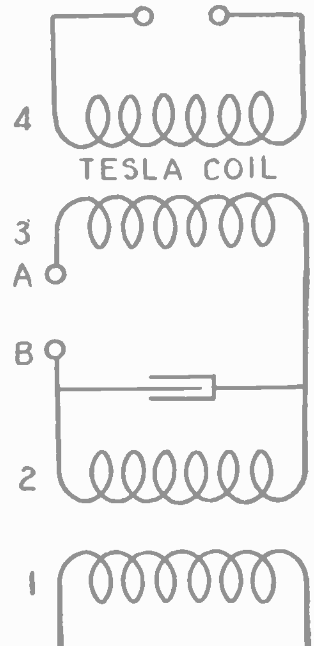


FIG. 2

Another form of Tesla coil circuit employing only one condenser. The operation of this circuit is very similar to that of the hook-up shown in Fig. 1.

Capacity and Potential

(520) George Kraft, Detroit, Mich., asks:

Q. 1. What is the relation between capacity and the maximum potential of a condenser?

A. 1. The capacity expressed in farads multiplied by the potential difference at the terminals expressed in volts gives the total charge of the condenser in coulombs. This means that for a given charge the smaller the capacity of the condenser, the larger will be its potential and vice versa. Also the larger the capacity of the condenser the more electrical energy would be required to charge it to a given potential.

The dimensions of capacity are $\frac{T^2}{L}$ and the dimensions of potential are $\frac{M^{1/2} L^{3/2}}{T^2}$

If we multiply these together we obtain $M^{1/2} L^{1/2}$ which are the dimensions of quantity. M is mass, L is length and T is time.

Q. 2. What happens to the voltage while the condenser is discharging?

A. 2. The voltage during discharge will decrease. This follows from the relation expressed above, that is, while the condenser discharges its charge decreases, and for a given capacity the smaller the charge the smaller the potential difference at the terminals of the condenser.

These relations were very thoroughly studied by the German physicist, Helmholtz.

The Experimenter's Bookshelf

Electrical System of the Automobile

AUTOMOTIVE ELECTRICITY. By Earl L. Consoliver, M. E. xv. 665 pages with index. McGraw-Hill Book Company, New York, 1925. $4.00.

Mr. Consoliver has here written the most thorough treatise on automotive electricity that has come to our notice. In his own words, "This treatise is not intended as an encyclopaedia, although it does contain information on practically all makes and types of automotive electrical and battery systems." The volume is profusely illustrated with remarkable simplicity and accuracy.

It is a book that will be especially valued by people who feel that no book can start low enough for them, for this one begins with a chapter on the fundamentals of electricity. Other interesting chapter headings that are indicative of the thoroughness with which the author handles the subject are: "Special Battery Ignition Systems, Low Tension Magnetos, High Tension Magnetos, Battery Charging Equipment, Battery Troubles, Armature Construction, Testing Instruments, Generator and Starting Motor Troubles."

Evidently, the book is not merely a theoretical discussion, but is, in a large measure, a practical handbook for the repair man in garage or electrical service work or indeed to any man who owns a car and wishes to gain that intimate acquaintance with its operation that is the only basis for efficient care. Along with the specialized discussions bearing particularly on automotive electrical devices, the author does not fail to present such theoretical elements as will throw light on the subject without confusing with unnecessary abstractions. For the student who wishes to master the subject, a large section of test questions is provided, while for reference work 16 pages of index have been compiled.

Direct Current Dynamos

CONNECTING AND TESTING DIRECT CURRENT MACHINES. By F. A. Annett and A. C. Roe. x. 231 pages with index. McGraw-Hill Book Company, New York, 1925. $2.50.

This book presents an elaborate treatment of the winding of direct current machines. A large number of full-page illustrations of armature windings help to clarify the text. The book seems especially well adapted for practical electrical workers in solving their winding problems and in giving them a better understanding of the equipment they are dealing with. No abstract mathematical formulas were allowed to creep into the text, although the temptation of treating the subject mathematically is very great.

Hardly any introduction is required to the winding of armatures. The book opens with a chapter on the Types of Windings, accompanying the discussion with photographs and development of armature windings. Simple and effective arithmetical examples are employed to illustrate the methods of computing the pitch of the various windings. The effects of changing the coil pitch and methods of taking data for the rewinding of armatures is extensively treated. A special chapter is devoted to the types of armature coils and how they are made. Methods of reconnecting for changes in voltage and speed are also carefully discussed. The author also gives several suggestions for locating and finding grounds in armatures and other important tests. A very interesting feature of the book is a chapter on "How to Construct and Use an Armature Testing Magnet." It is frequently convenient to use such a magnet for testing armature faults.

A number of our readers who have inquired concerning the winding of armatures and their testing will find here most of their queries authoritatively answered.

An Electrician's Handbook

STANDARD WIRING. By H. C. Cushing, Jr. 420 pages with index. H. C. Cushing, Jr., New York, 1924. $3.00.

To the veteran electrician, this book is no novelty for it has met with such general approval that at the time of the present edition it had already gone through 30 previous editions. These frequent renewals and revisions are necessary in a book of this type, for it treats especially of standard methods of wiring for electric light and power. Besides giving a good account of the standard practice and requirements, the book also offers numerous suggestions in time-saving methods. It abounds in the knacks of the trade that are the accumulated result of experience during long periods of electrical wiring practice. Very complete tables of wiring will be found in various parts of the book as well as simple formulas for the computation of diverse electrical and mechanical quantities. A thorough discussion of fundamental units is also given along with a brief electrical glossary. A special section is provided for the computation of adequate illumination for various requirements. This latter section is especially important because of the very prevalent ignorance of the essential conditions of correct location and intensity of illuminating sources, that exists in the electrical profession.

Electric Chime Ringer

(Continued from page 545)

is slowly moved up over them by the traveling iron core of the solenoid. The oil dash pot may be replaced by an air dash pot, such as found on some arc lamps and other electrical devices. The piston may be one of metal or wood with a few small grooves filed in its periphery in the same direction as its axis, so that as the piston is moved upward in the close-fitting cylinder, the air is allowed to pass by it but slowly. The top of the cylinder in any case would have to be fairly tight around the shaft secured to the piston.

The windings for the electro-magnets will probably not cause much concern to the average experimenter and builder of such an apparatus, as he usually will have a few electro-magnets from old bells, telegraph sounders, etc., lying around the shop. In Fig. 1, for instance, the electro-magnet (M) may be a medium sized electro-magnet with iron core, such as that from a telegraph sounder, or both magnets from a sounder with a suitable iron armature to permit both magnets to act upon it. Referring to the solenoid and small switch magnet in Fig. 8, the switch magnet at the top of the apparatus may be a small bell magnet, preferably rewound with heavier wire, say, about No. 16 cotton-covered magnet wire. As will be seen this magnet is in series with the solenoid, and thus its resistance must be quite low in order to allow enough battery current to pass through the solenoid to properly energize it; this can be overcome also by using a higher voltage in the battery.

With a little care and ingenuity these electric bell ringers may be operated from a 110-volt D.C. lighting circuit, but it is simpler and less troublesome to operate from batteries, as more flashing at switch contacts occurs with such high voltages. The solenoid magnet winding for operating the switch contact in the design of Fig. 8 may have a wrought iron or soft steel core ½-inch in diameter by about 4½-inch long. The spool ends of fibre or hard rubber may be about ⅛-inch to $\frac{3}{16}$-inch thick and about 1¾-inch in diameter, a brass tube occupying the center of the winding. The coil may be wound with twelve layers of No. 18 B. & S. single cotton-covered magnet wire. This will give a good strong pull on six to ten volts from dry cells.

Hydro-Electric Battery Charging Set

(Continued from page 549)

attached to the magneto; the size of the machine governs the size of the bearings. The bearings I used were 4-inch long ¾-inch wide and ½-inch thick, but of course it is best for the experimenter to use his own judgment as magnetos vary in size.

A D.C. generator of the type used in this set was described in complete detail in the January, 1924, edition of PRACTICAL ELECTRICS. However, I will add that it is a good idea to wrap or wind about 40 turns of small magnet wire around the magnets as shown in Fig. 1. The kind of wire used is found on the ordinary house bell, which can be found around the workshop or bought from an electrical shop for a few cents. The insulation should be perfect as a short-circuit will render the coil useless.

In the diagram Fig. (1) shows the method of winding the coils, and Fig. 2 shows the finished product. The reason for these coils is that if the generator is idle for a long while, the magnets may lose a lot of their residual magnatism. Without the coils the machine would have to be taken apart and remagnetized. This way after the machine is idle, all that is necessary is to start up the motor and then switch in the coils for a few minutes; when the coils are cut out, it will be found that the magnets have regained all the magnetism they lost. The coils must be wound in accord with polarity of the magnets and not in opposition. If when the machine is started up and the coils switched in the magnets get weaker, then reverse the wires to the brushes.

The windings consist of 5½-ounce of No. 20 B. & S. gauge I.C.C. or enameled copper wire. If a drum armature can be obtained, it is worth the trouble it takes to find it, as a laminated armature is much more efficient than a solid iron armature even in a small machine. The water motor is connected to the generator as shown in Fig. 5. The pulley and the shaft of the water motor have two small holes drilled in their shaft, the generator has one. If the water motor is to be used for grinding, etc., the pin is pulled out of the hole connecting the motor and generator; also the pin is pulled out of the pulley on the water motor's side, shoved up and hooked to the shaft of the water motor using the two pins one for each hole, so as to give the pulley a firm hold such as needed for heavy work. If no pulley is desired, the water motor may be connected to the generator by a piece of flexible heavy hose such as described in the issue of PRACTICAL ELECTRICS already referred to under the title, Hose and Clamp Flexible Coupling.

This outfit produces from 6 volts and 3 amps. up to 10 volts and 5 amps. and is suitable for charging any kind of storage battery.

Be sure to varnish any steel or iron that will come into contact with the water, such as the steel gong that supports the dippers, etc. Also keep all water from the generator as it is liable to cause a short circuit.

Litmus Paper Tests

MANY experimenters in chemistry when making tests with litmus paper as an indicator are in doubt as to whether the resultant change in color of the paper is due to the presence of an acid or a base. The following is a simple "memory formula" which can be relied on:

(1) Blue litmus in the presence of an acid will turn red; red litmus remains red.

(2) Red litmus in the presence of a base will turn blue; blue litmus remains blue.

Contributed by EMIL GUIDICI.

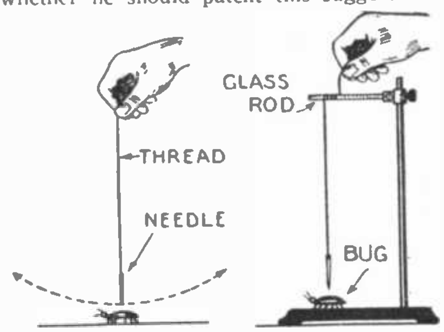
EXPERIMENTER'S PATENT SERVICE

EDITED BY JOSEPH H. KRAUS

ON this page every month we will give our readers the benefit of our experience on patents and questions pertaining to patent law. Years of our treatment of the subject of patented, patentable (and many unpatentable) devices has proved satisfactory to hundreds of thousands of experimenters. The writer, who has handled the Patent Advice columns of SCIENCE AND INVENTION MAGAZINE for the past seven years, will answer questions pertaining to the experimental side of Patents in this publication. If you have an idea, the solution of which is puzzling you, send it to this department for advice. Questions should be limited to Electrical, Radio and Chemical subjects. Another of our publications, SCIENCE AND INVENTION, handles patent advice in other branches. Address "Experimenter's Patent Service," c/o The Experimenter, 53 Park Place, New York City.

Sex Indicator

(7) R. K. Cunningham, Boston, Mass., writes that he has discovered that a small bar magnet or a small magnetized needle suspended from a thin silk thread and held in the hand over a male object will swing back and forth, and if held over a female object or material of a female animal, it will move ing a circular swinging motion. He asks whether he should patent this suggestion.



A.—In the first place you cannot patent a suggestion. Next, a system such as you have devised is not scientifically correct, and there is no basis for the findings that "if the object from which the material comes is male, the needle would oscillate back and forth, and if female it would move with a circular swinging motion." The magnetized needle has nothing to do with it. It is entirely a condition of the mind and an unconscious movement of the fingers. If you suspend the same needle from a rigid support, such as a ring stand, and place it in a room where there are no air currents, it will not move at all. You may argue that the electricity from the body must have some effect on the string also. The answer to this is that the current in the body is very slight and is not transmitted by a silk thread which suspends the needle. Furthermore, if you still believe that the body current has something to do with the phenomenon, we would advise you to twist the thread around an insulating rod of hard rubber or glass, and then to hold the end of the thread with your fingers. Make sure, however, that the point of suspension is the glass rod and not the fingers.

You cannot secure a patent on a device as worthless as this because it is inoperative.

Patent Protection

(8) William Kalman, San Antonio, Texas, who has an invention, asks for general information about patents and asks if he can keep any part of his invention secret.

Your letter has been received and we can give you what may be termed alternative advices. If you are quite convinced that there is money in your device and you wish to adequately protect it by a patent, go to a patent attorney. The metaphysics of the law, as patent law has been termed, are becoming more complicated year by year. The scope of new patents is more and more limited on account of the number of others which have preceded it. It is almost impossible to conceive of a fundamental patent being awarded for any invention now that there are so many at issue.

As regards the idea of concealing any part of your invention and getting a patent which is incomplete in description, so as really to disclose nothing of value to the community, the Patent Office will take care of this for you and will issue no such patent. The very word patent comes from the Latin word meaning to lay open. The fee you pay for a patent is supposed to cover the expense of the clerical work and of the examiner's work in the Patent Office and incidental expenses. The consideration you pay for your patent is really the disclosure of the invention so that others can practice it after its expiration. During its continuance, of course, no one can touch it or use it, and this protection of the inventor for the exclusive use of his patent for a term of 17 years is what the Government gives him for its disclosure. Thus you see there are two parties to the bargain; there is a buying and selling just as in any mercantile transaction.

Especially is a patent attorney valuable in the matter of claims. If a claim can stand in the courts, then the shorter it is and the less in it the more valuable it is. Many inventors feel that a claim half a page long is better than one of two lines. The only

object of making claims long is to impose a limitation on them such that they will stand up in court.

Now we come to the other alternative. If you do not feel that your invention is valuable enough to justify the services of a patent attorney in applying for a patent therefor, you had better drop it.

There is one thing more to be said: sometimes it is possible to protect oneself by absolute secrecy, but such a case is very exceptional and is almost invariably in some proprietary preparation; there cannot very well be any secrecy about a mechanical device.

Sometimes an invention can be placed, the purchaser assuming the expenses of patenting.

The Ark of the Covenant

(*Continued from page 523*)

"All right, Dan. It's a bet. Consider yourself entered on the ship's books."

He took hold of my hand and wrung it as if I had presented him with a medal.

"You're a regular fellow, Jimmy," he said. "And, say, Jimmy—if there's any shortage in the—in the ship's chests—don't forget I've got stacks, will you?"

"I won't forget, Dan."

Nothing would content him then but that I should write him out a list of the things he would need in his kit, and when that was done he made for New York as quickly as he could to buy the stuff.

The new *Merlin* was all ready late in the afternoon, and Milliken and I went up in her to try her for speed and for the synchronizing of the forward gun, which was an arrangement of our own. She answered perfectly. We had a new speedometer fixed which was numbered up to six hundred kilometers, and in one short burst the hand touched five-thirty. In that fact alone there was enough to make the government experts go crazy over her. Compared with the fastest known machine, she was a streak of lightning.

I will own that when I stepped ashore after the tests, I was almost drunk with excitement, and Milliken was little better. I was all impatience to hear the result of my father's letter to the President, and I got through to the old man on the phone.

"I was on the point of ringing you up, son," he said, "but you've saved me the trouble. The President has this minute left off speaking to me. He says he'll be ready to see you at eleven o'clock to-morrow. And I promised him you'd be on the doorstep of the White House right on time."

"Fine, dad."

"I won't tell you what he says to your proposition, but he was mighty flattering to your old dad. You'll learn from him to-morrow. Say, son—how did the new *Merlin* behave?"

"I won't tell you, dad—but it was mighty flattering to your young son. You'll learn from him at dinner."

I heard him chuckle, but it was characteristic of him to put up the receiver at once.

The Merlin Goes To The White House. An Interview With The President of the U. S.

IV.

At half-past nine next morning, the original *Merlin* took off with Milliken and two mechanics, and a minute or two later the new machine with myself and another couple of men streaked after them, headed for Washington. We took it easy, and landed in the seaplane basin of the Potomac just before half past ten. Right at eleven I was standing on the doorstep of the White House, never so nervous in my life. I had stepped in and was giving my card to the servant, when a white-haired little sturdy man came walking swiftly down the passage to shake me warmly by the hand. It was the President.

"You'll be young James Boon," he said, and opened his watch. "Right on time. Glad to see you. Come along to my work-room and tell me all about this wonderful machine of yours, and what's this free-lance policeman notion you have."

He led me into a little room, furnished half as an office and half as a library.

"Bless me!" said he. "And so you're Jimmy Boon's son. Are you as good a man as your father?"

"Not by miles, sir," said I.

"Ah! You might fall that short of him and yet be a good man," said the President. "Come, now. Just tell me as quickly as you can all you know about these raids. They are a matter of grave concern to me. Sit down—and shoot!"

Luckily, I had all the facts arranged in my head, ready for such a request, and I was able to give him a pretty concise summary of all that lay within my knowledge. While I was telling him, I had the opportunity of taking in something of his personality. I judged him to be hot-tempered, generous, and yet obstinate. A difficult man to drive.

"H'm!" said Mr. Whitcomb, when I had finished. "You seem to have kept track of all the evidence there is, and to have been untiring.

"I am glad to have from you the opinion of Sir Thomas Basildon and Lord Almeric. It is better than any cabled account. This is a very serious business, and the effects are already disastrous—"

He rose to pace the room in impatient short steps.

"There is a financial panic in London, Paris, and Berlin—business is being brought to a standstill in all those capitals, and the chaos is likely to spread. The cables this morning give cause for the deepest apprehension. Where it will all end I cannot foresee. The country has been swept from North to South without any trace being revealed of these marauders, and the Canadian authorities report no favorable outcome of the search of their territory. But we must keep on, cost the country what it may. I can see no other help for it. I agree that our only chance of running the raiders to earth is to be fully prepared for every emergency, to be certain that no means of following the slightest clue shall be neglected."

He turned to me with a keen look, that yet passed over me as if to some greater audience.

"In the mass of what the country must do to overcome such a terrible and bewildering menace," he said, "I cannot see that anything is to be gained by sticking close to rule and regulation. On the contrary, I believe that the enterprise you offer is better untrammelled. Therefore, you shall have every permit that is necessary, James Boon. I do not know from what point you will make a start, but you may have the luck—and I will venture that you have the intuition and skill—to light upon some clue which will lead to the clearing up of this mystery."

"Thank you, sir!"

His regard of me lost that absent air.

"No," he said, with a smile, "don't thank me. Thank rather your own proved value as a citizen. Or, if you will have it that that is to be depreciated, thank two excellent advocates in your cause."

"Two advocates, sir?"

"Why, yes. My old friend, your father—and my secretary."

"Your secretary, Mr. Whitcomb?"

"Would you like to meet my secretary? Very well, then—you shall." He went to a side door and called. "Kirsteen!"

And in answer, Miss Torrance appeared at the door.

"This is your advocate, Mr. Boon," said the President. "She has been pleading your cause ever since she opened your father's letter to me."

"I'm awfully grateful to you, Miss Torrance," I mumbled, as we shook hands.

"Uncle exaggerates," Miss Torrance declared. "I only pointed out that it would be foolish of the government to lose the help of one of its best airmen by sticking to silly rules. How was my Uncle Almeric when you left him, Mr. Boon?"

"He was wonderfully well, Miss Torrance. He sent every kind message to you."

"Dear Uncle Almeric! And how is my friend, Mr. Milliken?"

"Fine. He's in Washington with me."

"I must see him presently. And the *Merlin?*"

"Great!" I said. "She has three sisters now—"

"That reminds me of duty," said the President, opening his watch. "We must see this wonderful *Merlin*. Ah! Half-past eleven. The Air Secretary and his myrmidons should have arrived. Get your wraps, Kirsteen, if you are coming. We must not keep them waiting."

"Is the *Merlin* to be inspected at once—to-day?" I asked in surprise at this hustle.

"There will be some trouble if she isn't," said the President grimly.

CHAPTER TEN:

The Air Fight Off Mogador

I

In the new *Merlin* I took up two crack pilots and a designer, while Milliken in the original machine carried the President, Miss Torrance, and a bunch of experts. We flew at top speed until we were east of Delaware Bay, and there I fooled with the new bus, doing all the maddest stunts conceivable, until even the pilots with me were, I believe, a bit scared. The speed of the machine had amazed the experts, but her quick climb, that hovering flight of hers, and her astonishing qualities in manoeuvre astonished them still more. Long before we were back on the bank of the Potomac and heard the enthusiastic verdict of the authorities, it was fairly evident that the *Merlin* design would pass to the government at my own price.

I spent the afternoon in the offices of the Air Board, going over the drawings of the machine and into costs with the designers there. Meantime, Milliken and two mechanics had gone by rail to Gardiner Bay to bring back the other two machines, which were to be purchased by the

government. When I rejoined the President and Miss Torrance that evening for dinner at the White House, I had in my pocket a bank draft for the handsome price which was paid for the *Merlin* design and the three new buses. The quick settling of the deal was due to the President, and when he and Miss Torrance and myself were alone after dinner, I tried to thank him. He put a hand on my shoulder in a kindly way, shaking me, and tried to stop me saying anything.

"Why, son," he said, "there's no need for thanks. You brought along your design just when it was most needed, and we'd have been fools to let what Kirsteen calls red-tape hinder the concluding of the bargain. We ought to thank you publicly for giving us such a wonderful plane. But I have something for you—"

He produced an evelope and handed it to me. In it was a letter appointing me for special service with the air police, and mentioning Dan Lamont and Milliken as my assistants.

"Turn back the front of your jacket," said Mr. Whitcomb, and when I did so he pinned a little silver badge to the lining. It was the badge of the Secret Service.

"There!" said he. "Now, in the morning at ten o'clock you will go to this address." He handed me a card on which a direction was pencilled. "You have only to give your name to the doorman, and he will take you right to the man who nominally will be your chief. Don't bother to ask his name. It is seldom the same two days running. I want you to see him because there may arise an occasion when it will be impossible for you to report direct to me, and in that case you will report to him. Ordinarily, you are responsible to nobody but Ben Whitcomb. Get that?"

"Yes, sir."

"Very well, then. Burn that card when you have memorized the address."

"I can do that now, sir," said I, and dropped the card into the open fire.

"Good," said the President. "Take Lamont and Milliken with you to-morrow."

"I shall have to get Dan Lamont on the phone right away, then."

"You'll find Dan Lamont at your hotel when you get back there to-night," said the President with a smile.

"Why—he's in New York!" I blurted.

"Not at all," he laughed. "He's on his way to Washington. We phoned him to come right off, and fixed a room for him at your hotel. At least, my secretary did."

I turned to Miss Torrance, and it came to me that she was just the prettiest girl I had ever seen. There was a little faint flush on her cheeks, and her eyes were shining. As if she were a little breathless with some excitement, her lips were slightly parted.

"It's mighty kind of you, Miss Torrance," I mumbled, "to take so much trouble for me. I don't know how to thank you."

"Don't try, please—it was Mr. Milliken—"

"Milliken!"

"Milliken and the *Merlin*—and, oh, the whole thing," she cried. "You two and that lovely plane—and that modest little man, Mr. Lamont. I envy you, all four. Next to being a man myself and joining you—the best thing I could do was to see you got your chance. You're lucky in your friends, Mr. Boon."

"I am that," I said warmly. "Especially if I may number you among them?"

Then I felt my ears grow hot, and my neck go red at blurting this. It seemed so gauche after all she had done for me in friendship.

"That sounds ungrateful and silly," I stammered. "But I only wanted to hear it from you—"

She was a little bit rosy herself, but she held out her small fist in a frank way, and her serene eyes looked right into mine.

"Isn't that the American way?" she smiled. "To shake on it?"

"Sometimes," I said, and took her hand.

"I'm green with envy at your luck," she said, "though you deserve it, every bit—but I'm with you and the crew of the *Merlin*, heart and soul."

"That's just fine!" said I, and wished that kissing a girl's hand was still the fashion. Presently I took my leave of her and her uncle.

Sure enough, when I got back to the hotel, Dan Lamont was waiting for me in the foyer. He immediately dragged me up to his room to look at the new kit he had bought. There were bags of it. He must have cleaned New York.

"Say, Danny," I remarked to him, "what do you think you're making the trip on—a cargo-steamer?"

"Aw, Jimmy!" he pleaded. "It's just a few little things I thought we'd find useful—"

"I gave you a list, didn't I?"

"And I stuck to it, Jimmy—faithfully. I got three or four of everything you said. Then I got them to throw in some extra comforts for you and Milliken."

"The only extra comforts that Milliken and I will appreciate, my son, are maybe a few extra bands of shells, or another litre or two of gasoline. You'll have to leave five-sixths of this behind, Dan."

"I know I'm a goat when it comes to spending, Jimmy," he said. "I get so blamed enthusiastic."

"Well," said I, "when you bought this lot you certainly were in no fit of depression!"

He looked at the collection with a touch of despair for a minute, then he brightened up.

"Tell you how, Jimmy," he said. "We'll leave this stuff at our base and draw on it whenever we want new outfits."

I took my letter-of-marque from my pocket and flipped it over to him.

"Then," said I, "perhaps we'd better have the President alter this so that you'll be definitely commissioned Quarter-master General to the Force."

He read the President's letter with growing excitement, then danced about the room.

"Bully for you, Jimmy!" he cried. "Oh boy! I knew you'd pull it off!"

I folded back my jacket and showed the badge.

"Consider yourself under arrest," I said.

"My!" he gasped. "You've gone and joined the Hicksville Temperance Cadets!"

So I put him in one of his own kit-bags.

Next morning Dan and I collected Milliken, who had returned to Washington late the previous night with the two new buses, and the three of us then went off to the address given me by the President. It turned out to be a modest little office in a back street. With its window-screen of colored bamboo beads and its brass plate on which the name had been made undecipherable with years of rubbing, it might have been the office of either an attorney or some old-fashioned importer.

The Hero is at Work Under the Secret Service

We were led by the doorkeeper into the presence of a quiet, grey-haired man in a nondescript grey suit, who presently was chatting to us in a pleasant, flat voice that seemed to have no high lights to it. He spoke of nothing much except the weather and the prospects of business during the year.

"Business is likely to be a little upset by these raids," I ventured, apropos of the last subject, trying to give him a lead to our particular affair.

"Ah, yes," he said softly. "Most annoying—most annoying—"

He rose and held out a limp hand.

"Glad to have seen you, Mr. Boon—and you, Mr. Lamont—ah, Milliken," he said, quietly dismissing us. "Ah—if in your travels you should have any affairs with my firm, just look up the local agent for Aunt Mandy's Soap. You won't forget—Aunt Mandy's Soap. Buy a packet. We are running that line pretty strongly at the moment. Branches everywhere."

And with that he gently shepherded us out of the office.

"Well," said Danny, when we were out in the street, "what do you know about that? Aunt Mandy's Soap—buy a packet!"

"When in doubt we buy a packet of soap, and so find the nearest S.S. agent, I take it," said I. "Queer sort of fellow that—doesn't seem to have energy enough to wink—"

"Got us weighed up all right," grunted Milliken. "Daren't breathe but he saw it. Stringy guy, too—wouldn't like to fight him."

"Quit joshing, Milliken!" I protested. "Why, he's like a wet rag."

"Don't you believe it," Milliken said stolidly. "Chest like a barrel. Arms like a monkey. Notice when the pencil rolled off his desk?"

"Not particularly. Why?"

"Never reached the floor," Milliken said, gazing at the sky. "Caught it without any noise. Quickest reflex I ever saw."

Which shows, I suppose, that if Milliken spares his tongue, he makes full use of his eyes. Danny and I had noticed nothing about the chief—as the quiet man in the back street might be called—except that he seemed bored to death with the mere effort of living.

II.

The next ten days passed slowly. Milliken and myself were engaged in demonstrating the new *Merlin* to the government flying-men, and at the same time we had to oversee the refitting of the armament to the old machine, with other alterations necessary for our campaign. Dan Lamont was kept busy collecting stores, and on his own account he was making a selection of instruments which he thought might help him in solving scientific problems connected with the raiders.

With all three of us dead eager to be setting out, the delay was irksome, but we consoled ourselves that we were doing good work in putting the pilots wise to the efficient use of the machines, and that in any case it was better to wait for the next move on the part of the raiders.

The *Merlin* was fully ready for action by the middle of the week following our commission. The fighting top was fixed, and we had shipped all stores and ammunition. She carried four guns. We had dispensed with two of the smaller, so that we now mounted the fore and aft guns firing half-kilo shells, and a machine gun on either quarter. The arrangement was that Milliken or myself, whichever of us happened to be piloting, should handle the bow gun, while the other should work that at the stern. Dan Lamont, if not occupied in scientific observation, was supposed to turn his attention to the quarter guns, firing on the side handiest in any encounter. Incidentally, he proved an apt pupil under the instruction of Milliken and myself. We arranged the ammunition bands for each of the guns with great care, so that there would be no hitch in a crisis, and we put the spares where they would be handy for fitting at once.

Dan made it his job to render us as immune from the raiders' gas as he knew how. On his advice, we laid in a cylinder of oxygen, and fitted air tight coverings on all openings. The gun embrasures we filled with fabric, double pleated like camera bellows, and pierced to take the barrels and telescopic sights and fitting tightly to them, but flexible enough to permit a good arc of fire. The material was some close-woven asbestos stuff of Dan's own choosing, and he said it would not only keep out the gas, but would resist the heat of the gun-barrels after heavy firing. Our general idea was that should we get into action with the raiders we should immediately close all apertures, turn on a thin stream of oxygen, and do our fighting from a hermetically sealed cabin, a quicklime apparatus absorbing the carbon-dioxide.

Dan also had caused to be fitted under the hatch a bottle arrangement for automatically taking a sample of the gas, should we get into it.

During the fortnight in Washington we frequently met Kirsteen Torrance, and her uncle, the President, less often. She was inclined at first to think us a trifle slack about getting down to business, but the President persuaded her that we were doing the right—and harder—thing in waiting. Kirsteen took a deep interest in our preparations and was often in the *Merlin's* shed. She renewed acquaintance with Milliken, who greeted her every appearance with his widest grin and delighted to explain to her the smallest detail of our outfit. We thought of her as our mascot.

We had an idea that the next of the raids would most likely come on the Great Lakes, and we decided that if we got no news by the evening of the first Sunday in May, we should make a hit-or-miss start for the Buffalo end of Erie on the Monday morning. News came to Washington by radio, however, that scrapped our plan at once. Dan and I were having tea with Miss Torrance at the White House, when the President came into the room with a flimsy in his hand.

"Flying orders, boys," he said. "Ships have been stopped to-day on the Cape route from England."

"At what point?" I asked, and got to my feet in a hurry.

"Northwest coast of Africa—between Madeira and the Canaries. By daylight, too."

"Come on Danny," I said. "We'll get off right away. You'll be breakfasting at Funchal by five o'clock to-morrow—"

"Quick work!" said the President approvingly.

"Good-bye, Miss Torrance. Good-bye, sir—"

"Nay, nay," said Mr. Whitcomb. "Kirsteen and I will see you off. I'll ring for an automobile. We'll go together."

The Merlin Starts Off In Armored Trim to Attack the Enemy

It was close on five o'clock when we took off from the basin by the Potomac, and a clear "Godspeed!" from a bright-eyed Kirsteen, a hearty "Good-luck, boys!" from the President, were the last words we heard as we set out on our venture.

Night came on us very quickly, for we were flying towards it, but while the light lasted Dan took a final lesson on the machine-gun from Milliken. With the dark we hit into a severe storm, which tested the *Merlin* very thoroughly. We had to climb high before we got out of a heavy driving rain, and when we had avoided that we came into electrical disturbances that played the very devil with our compass. It was tricky and difficult flying, for the lightning flashed above and below us, dazzlingly brilliant, and the atmosphere was terribly pocketed, so that we pancaked in a most sickening fashion. The smash of the thunderclouds was deafening. There were times when only the fact that Milliken was standing on his feet persuaded me that we were not flying upside down. The disturbed area must have covered ten degrees of longitude, for we were in it close on two hours. At last, however, we passed out of the storm belt and could see the stars, and we were more sure of our course as a consequence.

Milliken and I spelled each other every two hours, while Dan, once the interest of the storm was over, slept peacefully. It was bright day when we sighted the Azores, though our clock showed only half-past two. Three hours later we were swaying gently on the swell in the very exposed Bay of Funchal.

Milliken cooked breakfast on the gasoline stove, then after a visit from the port authorities Dan and I went ashore. We could get no official information about the raids that was worth considering. The Portuguese did not seem to care a red cent about the stopped liners. We had better luck at Blandy's, where Englishmen were in charge.

There were three acts of piracy on the Sunday, two Union-Castle liners and one belonging to the R.M.S.P. Co. being the victims. In each case the strong-rooms had been the objective, specie being taken from all three ships, and from a Union-Castle liner, which was homeward bound, the raiders had made a considerable haul in diamonds. The method of attack was similar on each ship: a sudden descent from the sky by the airship, swift and unexpected, and almost immediately the anaethetizing of every soul aboard, close

on a brief period of terrible panic among the passengers and crew. This last was a ghastly feature which had been missing from the night raids.

For a week, the weather being fine enough to permit a stay in the exposed harbor, we made Funchal our base, and we haunted the shipping routes from the coast of Spain to the Cape Verde Islands. But we had not the luck to sight our quarry. The following Sunday, while we were making towards the Azores, we intercepted a radio which told of raids on the north Atlantic shipping. We filled our tanks at San Miguel and cast a wide circle north into the sea lanes, flying until dawn on the Monday morning, without result. We returned to the Azores.

It came to Dan Lamont and myself simultaneously that these very islands would make an ideal base for all the known operations of the raiders, a notion that seemed to hit all the international searchers a little later. The seaplane base began to fill with British, French, American, and German machines, until by the middle of the week there was hardly mooring room for another bus. Meantime, Dan and I had gone ashore to test the Aunt Mandy's Soap scheme. We bought a packet, and sure enough made the acquaintance of an alert young American who had an office in a quiet back street. We did not need to introduce ourselves. He greeted us by name as soon as he saw us.

We enlisted his help for a search of the Azores, and while his dago myrmidons scoured the land, we examined every nook and cranny from the air. We raised no game whatever. Altogether, we spent another fruitless week in the Azores.

"Look here," the distributor of soap said finally. "There's a dandy landing-place for an airship on Madeira. I've just remembered it. A plateau, Lord knows how many feet up, towards the west end of the island. They call it the Paul da Serra—a barren place it is—utterly deserted. I'd give that the once-over, if I were you. I think you're on a false trail in this particular group of islands."

Well, we were just sick of the sight of all that unused ammunition in the cockpit of the *Merlin*, and our soap friend's description of the Paul da Serra certainly did make it look like an attractive landing-place for an airship.

It was nearly a fortnight since we had left Washington. May was more than half over, and we were still short of the fight we wanted. Anyhow, a faint hope seemed better to us than none, so we made for Funchal once again, with the intention of flying over the plateau on the early morning of the next day—Sunday it was.

As luck would have it, this was the time chosen by the *Merlin* for her first breakdown. It was nothing much, just a fleck of enamel stuck by some chance in the jet of one of the carburetors. We could have flown all right, but Milliken and I did not want to get away with two cylinders missing. The locating of the trouble was enough to delay our start until long past dawn. It was seven o'clock before we got over the plateau and, as will be shown later, that fleck of enamel lost us an excellent chance. The Paul da Serra was bare when we flew over it—but it had been occupied not an hour and a half before.

It was the merest chance that sent us northward on patrol, for we had considered another flight to Cape Verde Islands. But northward we went. There are some would say we were urged by fate.

At Last the Enemy is Sighted and all is Prepared for the Attack

III

Our northward course had lasted barely half an hour, when far below and ahead of us there opened out a situation that had about it more than a touch of drama.

Broadside to our path lay a liner, spick and span to the smallest detail in the clear air of the summer morning, but so far away as to be a miniature ship. Almost nestling on her tall masts there hovered the long silver shape of an airship!

Dan and Milliken were doing small chores in the cabin behind me, and I found myself calling them—somehow in a whisper.

"By Christopher, old man," Dan breathed, "we've got 'em at last!"

Milliken's only comment was to pull the breech-cover off my gun and set the belt of shells.

"Keep high, sir," he muttered, when that was done, "and drop on them—*quick!*"

"That's the idea," I whispered. "Close all openings. Action as rehearsed."

"Right, sir!"

He and Dan quickly cleared for action, while I gave the engine as much gas as it would take. The *Merlin* leaped forward at dizzying speed. And now we saw what we had previously missed, that we were not alone in our hurry to the scene. From the east raced a warship, a plane-carrier we could see from her forward platform, and British from the fleck of white and red at her peak. Her distance from the liner could not have been more than sixteen kilometres, and the white surge at her stern and bows showed how quickly the distance was being covered. Neither the airship nor the cruiser, I felt certain, had spotted the *Merlin*. If the cruiser sent up a plane, we would have to be spry to get in the first shot.

"Stations, boys!" I yelled, then, for I saw the airship begin to rise from the masts of the liner.

"I'll dive below her, Milliken. Burst her as we pass below!"

"Aye, aye, sir!"

Down, down, down we streaked—quicker than ever kestrel swooped. My shoulder was snugged in the piece of the gun, and my finger was trembling on the trigger. Up, up, up to meet us came the mass of the airship till her side loomed like a great wall. I flattened then, and every fibre of the *Merlin* protested at the strain. Suddenly my gun blatted as of its own volition. I could just glimpse the gouts of flame as the shells burst in the grey side of the airship, before I had to dive under her—then behind me I heard Milliken's gun give voice in a prolonged roar.

The enemy must have risen quickly, for I found the *Merlin* still a good height above the level of the sea. The speed of the dive—done with the engine almost at full throttle—took us far beyond our quarry, since I could not turn without depriving Milliken of his shot. I pressed the foot-bar for the turn, and Danny loosed off excitedly.

"Hold your fire, Danny!" I yelled. "We're not near enough!"

"Hell, Jimmy!" he shouted. "Gimme a chance, will you?"

Despite my climbing turn, we had lost the level of the rising dirigible and we now had to climb at a steep angle, but I set the *Merlin* to the task, all out. She answered willingly.

High above us floated the silent grey shape of the airship, and it seemed as if she were disdainful of the worst we could do her. No answering burst of fire came to us, no sign that anyone moved on her. She was uncannily still. It was amazing that she still could float level, for at least three of my shells had taken effect on her envelope, and Milliken was not the man to expend ammunition unless his target was plumb on the cross-hairs of his gun-sight. But she floated horizontally, rising quickly, apparently unharmed.

We were gaining on her, I thought, but the angle at which we had to climb seemed likely to take us clean under her, so I gave her a burst of shells before turning to spiral. As we came round, Danny's gun stuttered out a long roll—it must have been nearly a drumfull—and presently Milliken's heavier metal took up the ground bass of the chorus, till the cabin was clamorous with the roar, through which came the thin tinkle of spent shells falling. Still no answer from the enemy.

When the spiral brought us round so that the grey shape filled the field of my gun-sight again, I began to notice that the ship floated in a thin pinkish haze that shimmered, as one sometimes will see the heat do as it rises from a hillside in summer. It was a curious effect, curious enough to hold my attention even in the excitement of that moment, and I called Danny's attention to it before opening fire on the target. But as I pressed the trigger, the haze enveloped the *Merlin* herself, and a sort of dancing refraction spoiled my aim.

"Wonder if that haze has anything to do with their gas?" said Danny in my ear as we swung round once more, and he added something that was drowned by the noise of Milliken's gun.

Just at that moment, to my intense disgust, the engine of the *Merlin*, which had been working beautifully, gave a despairing whine and petered out. I felt the bus slip back, and I flipped up her tail so that we came into a head dive. As we came down the engine picked up and failed once or twice in an odd fashion, till at last— when I had got the bus into her steady hovering descent—it stopped altogether. We alighted gently on the face of the sea.

At once Milliken sprang for the engine hatch, but Dan Lamont seized him by the arm.

"Don't open anything yet, Milliken!" he yelled. "Not yet—we're still in the haze. It might be the gas!"

"Gas—hell!" said Milliken. "I want to see what's happened to the engine!"

"Jimmy!" Danny cried in distress, as the mechanic gently put him aside.

"Just a moment, Milliken," I intervened. "Let's think this thing out—Mr. Lamont may be right."

"Right, sir," said Milliken, and stood aside at once.

The pinkish haze lay about us as we rode the sea. To the north of us the liner still wallowed in the troughs, and the British cruiser was coming up hand over fist from the east. The airship floated motionless in the sky to the south of us, seemingly none the worse for our attack, nor making any attempt to get away. My glance fell on the clock attached to the control-board.

"Mighty!" I exclaimed in surprise. "It's hardly ten minutes since we sighted her!"

"What's to be done about the engine, Mr. Boon?" Milliken demanded.

"We'll be guided by what Mr. Lamont says, Milliken. What's your notion, Danny?" I asked.

Dan was on his knees working the bottle for sampling the gas. He looked up, then rose.

"I've worked the bottle," he said, "but I can't test the gas here. If this haze is what I think it is, we can't open anything for long without being doped. This is what I say. It's damned unscientific—but I don't believe in tests even on white mice. Let me open a port slightly, and take a whiff—I'm certain the raiders are averse to the use of anything lethal. If I keel over, shut the port quick and bung my nose up against the oxygen tube, and leave me to recover. That will be enough if I don't show signs of choking—"

The Gas Question. A Sample Bottle of the Gas is Secured and Precautions Taken Against It.

I was taken aback at having to sanction such a proceeding, but there was no time to argue the matter.

"You're O. C. Stinks, Danny," I said quietly, "and what you say goes. Is that the order?"

"Sure it is," said Dan, a little breathlessly.

"Right," I said. "If I didn't think—I pray God it's nothing worse than the usual gas—"

"I don't see why they should change their tactics now," said Dan. "If I don't come around, try the ether injections I showed you. Stand by, boys."

He went quickly to a porthole and undid the screw, then swung the cover aside and stuck his head out.

"It's the ga—gas—allri'—" he muttered with a funny little smile. Then he seemed to crumple, and I caught him as he fell. Milliken whipped the cover back into its place and threw in the fastener, while I gently laid my friend down with his fair head against the oxygen nozzle.

To be Continued.

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STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACT OF CONGRESS OF AUGUST 24, 1912,

Of The Experimenter, published monthly at New York, N. Y., for April 1, 1925.
State of New York—
County of New York, ss.

Before me, a Notary Public in and for the State and county aforesaid, personally appeared Hugo Gernsback, who, having been duly sworn according to law, deposes and says that he is the Editor of The Experimenter, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, reqnired by the Act of August 24, 1912, embodied in section 443, Postal Laws and Regulations, printed on the reverse of this form, to wit:

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Publisher, Experimenter Publishing Co., Inc., 53 Park Place, New York City.

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Managing Editor, Thomas O'Conor Sloane, 53 Park Place, New York City.

Business Manager, Robert W. De Mott, 53 Park Place, New York City.

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H. Gernsback.

Sworn to and subscribed before me this 16th day of March, 1925.

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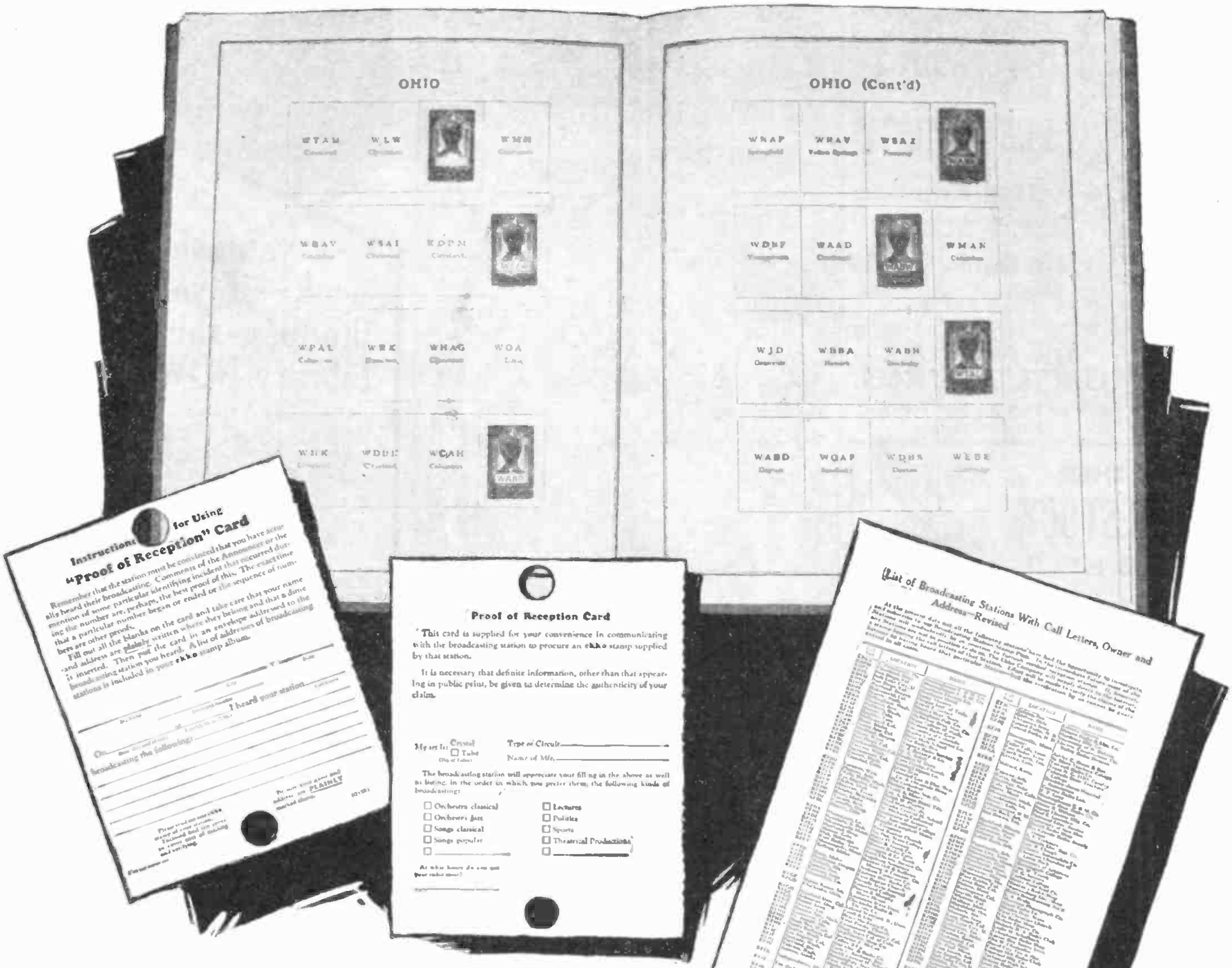

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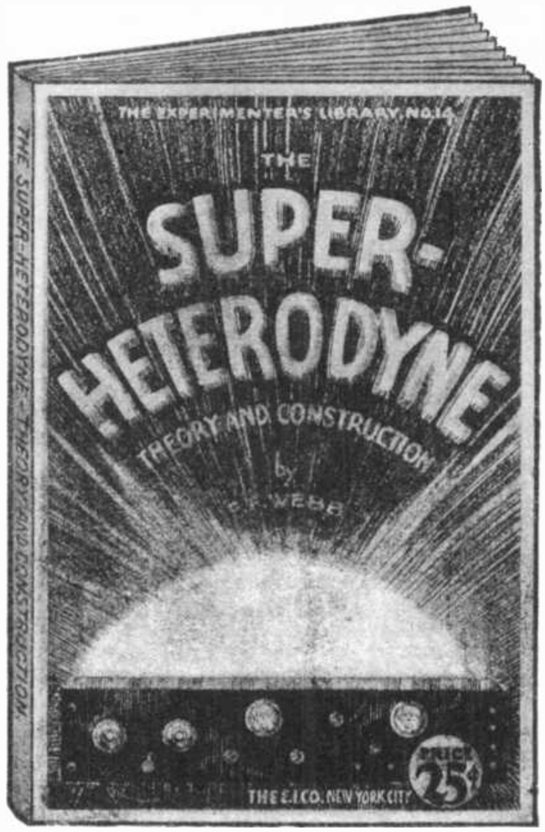

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