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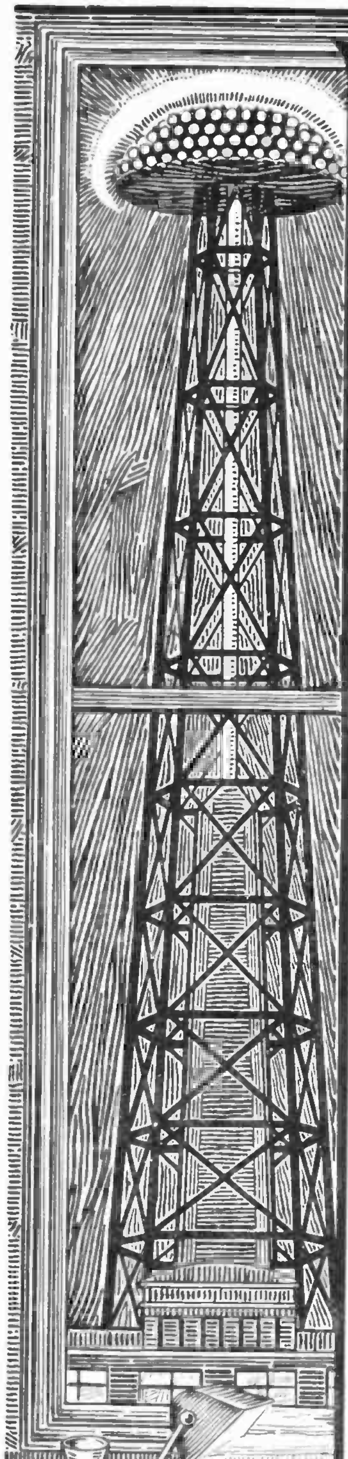

The EXPERIMENTER

Vol. 4 **Contents** No. 7

FOR MAY

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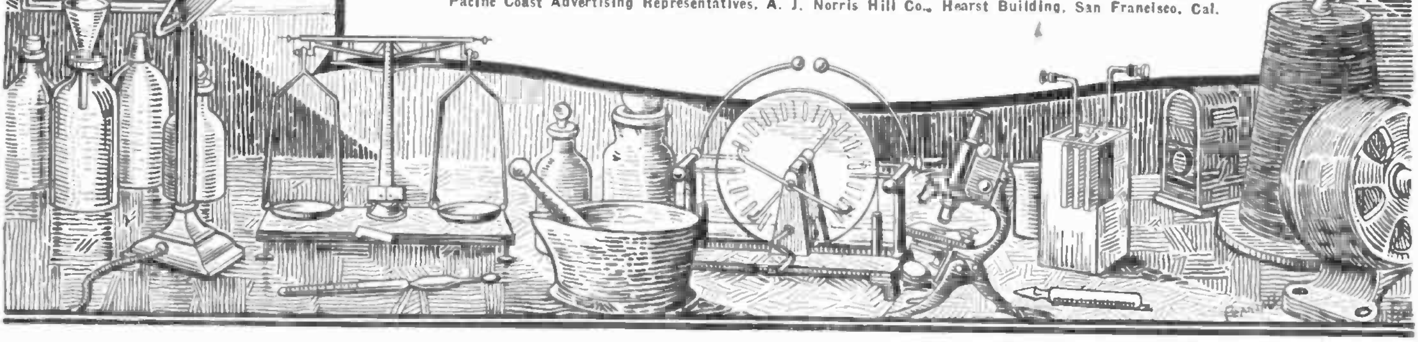

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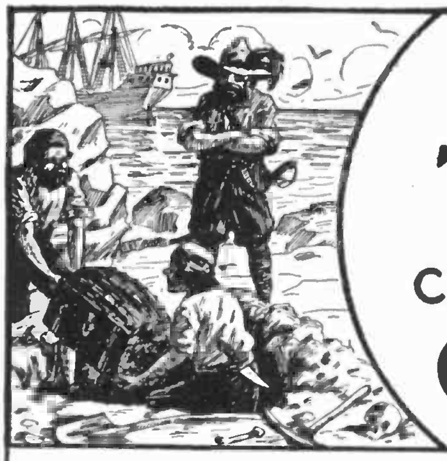

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Volume 4
No. 7

The EXPERIMENTER
Electricity ~ Radio ~ Chemistry

May
1925

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

Chance in Experimenting

By Hugo Gernsback

An ounce of experimenting is worth a pound of theorizing"

EVERY experimenter is cognizant of the fact that as he goes along in his work many unforeseen and totally unexpected results crop up continually. It should be the foremost duty of every good experimenter to make copious notes any time such occurrences happen. While it is not always possible to draw conclusions from such occurrences, maybe six months or a year later, when reviewing the notes, the experimenter will have suggested to him something which in time may prove most valuable. Chance happenings of this sort are sometimes most important, and as a rule it takes a high degree of intelligence to interpret the occurrence and put it successfully to work.

Following are related a number of good examples of the above:

Hughes, in 1855, was working on a printing telegraph instrument. His object was to obtain synchronization. He afterwards said that he got the hint from two darning needles which he presumably caused to vibrate with equal frequency.

The invention of the telephone was due largely to chance. Alexander Graham Bell was working with his musical telephone, composed of reeds of steel vibrating to particular notes, which were brought into vibration by their respective electromagnets. While Hubbard, Bell's assistant, was operating the key, the contacts welded from the heat and cohered. This naturally closed the circuit so that the reed stuck to the magnet. Hubbard, in trying to detach it with his finger, innocently started the reed into vibration, and the vibration naturally was repeated at Bell's end of the line. Bell became wildly excited, detecting in this a clue to the speaking telephone, to which he was then giving only part of his attention, because his financial backers, Sanders and Hubbard, insisted upon his working on the musical one. The experiment was the reproduction of sound in a closed circuit, an essential feature of telephony.

Daguerre, a noted experimenter and inventor of the Daguerrotype, while treating a metal plate with iodine, happened to lay a silver spoon on it. The image of the spoon, which probably was nothing but a silhouette, appeared upon the plate. Daguerre, much astonished by the results, subsequently coated a silver plate with iodine and obtained a faint image. He put the coated plate into a closet containing a lot of various chemicals, simply to keep it there for a while out of harm. The next day, when he took out the plate, the image had developed. The cabinet contained many chemicals and it was impossible for Daguerre to know which of the chemicals had given the beneficial action, so he worked out a system of elimination to determine which chemical was responsible. This action of his proved that he was a careful and most intelligent experimenter.

He put plate after plate back into the closet and got the developed image night after night, although each time he took out one of the chemicals. When the closet was completely empty to his mind, he put an exposed plate back just the same, and, notwithstanding the presumable absence of chemicals, the image developed. After much investigation, Daguerre found that a little mercury had been spilled in the closet, of which mercury he had had no cognizance. It was, therefore, the mercury vapor which had done the developing. This was the basis of the Daguerrotype, invented simply because of the persistence of an ardent experimenter.

Not all experimenters are very clever nor wide-awake. A case of this may be proven by Oersted, in 1819, who actually worked 13 years before he made his magnetic needle respond to the current passing near it.

Elihu Thompson, on the other hand, as reported by the Franklin Institute, was a careful experimenter of much imagination. He noticed that the wires of a Rhumkorff coil through which a heavy discharge had passed were welded together. This gave him the clue to electric welding.

The same experiment probably was made thousands of times by other experimenters before him, but Thompson had the imagination to see that this little welding operation could be used commercially and in a large way.

Rambling Reflections on Terrestrial Fields

By Philomath

"SIR," writes one of our correspondents who modestly asked us to withhold his name, "In connection with your recent speculations on ether, I am inclined to agree with the Editor in that I don't find it necessary to use the ether hypothesis in explaining various electromagnetic phenomena. In my opinion, radiated energy moves through a vacuum in the form of small quantities, or quanta, of energy which move like discrete particles of matter. However, I find difficulty on this basis in explaining the existence of electromagnetic fields, as for instance the magnetic field of the earth or indeed its electric field. I would appreciate your discussing these fields in some future number of THE EXPERIMENTER."

We confess that without the ether hypothesis we cannot account for the existence of stationary electromagnetic fields and as regards the fields of the earth, we cannot even explain their origin. This question of the earth's electric and magnetic field has long been one of the unsolved problems of terrestrial physics, and as yet no satisfactory explanation has been rendered. Among the many physicists who have concerned themselves with the solution of this problem, Professor Swann of the Royal Society is prominent, and has recently advanced numerous explanations.

If by the circle in Fig. 1 we represent the earth, the thickness of the line may be taken to represent the earth's atmosphere and electric field. This electric field is due to charges on the earth. Now these charges are continuously leaving the earth, the charges being given up to the atmosphere. This interchange of charge is so rapid that in ten minutes 90 per cent. of the earth's charge would disappear if it were not replenished. The flow of charge constitutes an electric current which over the surface of the earth totals 1000 amperes, or in other words enough to light about 2200 50-watt incandescent lamps.

To one unacquainted with the conductivity of the earth's atmosphere, it seems strange that so large a current should pass through the air. The explanation is, that due to various ionizing influences there are 1000 positive and negative ions in every cubic centimeter of the air. This, however, is not at all a large number when we remember that there are altogether 30,000,000,000,000,000,000 molecules per cubic centimeter of the atmosphere. Professor Swann evaluates the conductivity of the atmosphere in a striking fashion; a cylinder of air, one inch long, has the same resistance as a copper cable of equal cross-section reaching from here to the star Arcturus, 20 times over, that is, 1,000,000,000,000,000 miles long.

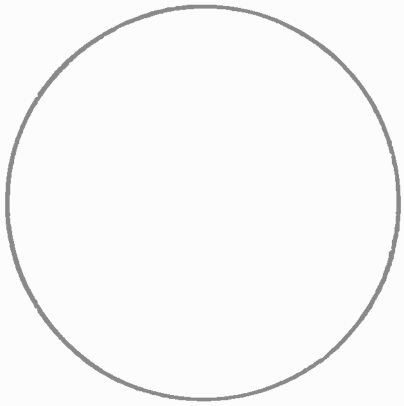


FIG. 1

If we let the circle in this figure represent the earth, the thickness of the line would be proportionate to the size of the earth's atmosphere and electric field. What mysterious forces in this large mass of matter give rise to that electric and magnetic field that we detect at the surface?

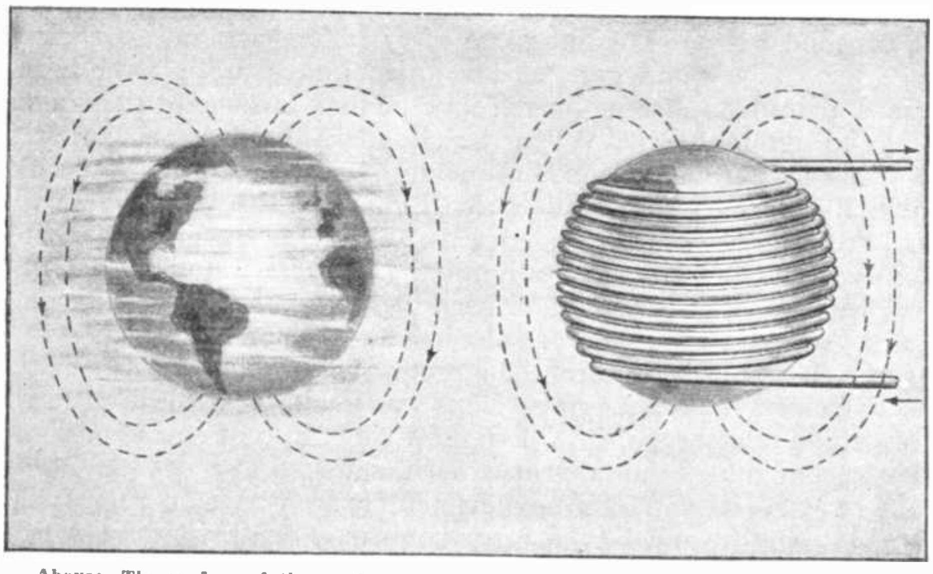
With these facts in mind, it is difficult to account for the permanent charge on the earth's surface. Perhaps some of our readers can advance an explanation.

The earth's magnetic field is no less mysterious.

The earth's interior being extremely hot, a magnetizing force must continuously be present to maintain its polarity. The question is, whence comes this magnetic force? Is it due to the rotation of a charged body? For the earth being a charged sphere, its rotation is in effect a flow of current and will set up a magnetic field similar to the field of a large coil wound around the earth (Fig. 2).

But there are difficulties in the way of this explanation, for this rotation theory does not explain the variations of the magnetic poles of the earth, and besides, such rotation would set up a field only 0.000,000,01 of the earth's field. This explanation is therefore inadequate.

Another explanation may be advanced on the basis of gyroscopic force exerted on the atoms in the earth. Referring to Fig. 3, if the axis AB around which the wheel W rotates is itself made to rotate around the axis CD, there will be a tendency on the part of axis AB to coincide with CD. Now imagine myriads of atoms with their rotating electrons disposed in a haphazard fashion and all revolving about the earth's geographic axis. Obviously, the gyroscopic force will constrain the atoms to take up positions where their axes will be parallel to the earth's axis. In consequence, the magnetic fields of the atoms will be parallel to one another, and will reinforce each other. Is it not possible that the earth's magnetic field may in this way be due to the magnetic field of the individual atoms held in position by the gyroscopic force? This explanation seems very plausible and, in fact, lends itself to experimental verification, for an iron bar can be magnetized by rapid rotation as in Fig. 4. However, computations show that such gyroscopic magnetization would produce a magnetic field only 0.000,000,02 of the earth's magnetic field, so that this hypothesis must also be discarded as inadequate.



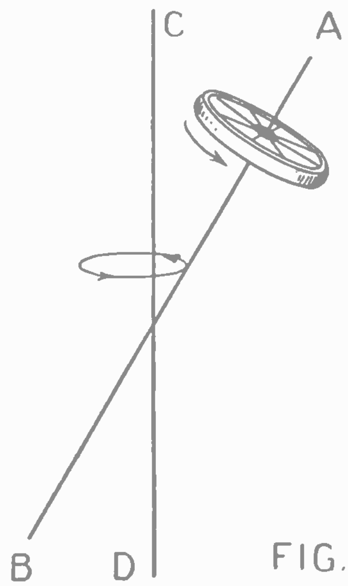


FIG. 3

Above: The surface of the earth bearing a charge, its rotation is in effect equivalent to a large coil of wire carrying a current. Both set up magnetic fields similar to the earth's field.
Right: If the axis AB carrying the rotating wheel is revolved about the axis CD, gyroscopic force will constrain AB to take a position parallel to CD. Such constraining forces are at work upon the atoms of the earth as the latter revolves about its axis.

Another, but very bold and striking, theory can be based on the inertia of electrical currents. It is well known that a current once started in a circuit will continue to flow for a little while after the electromotive force is removed; the reason the current decays is that the circuit offers resistance to its flow, and to overcome this resistance a force (emf) is necessary. The lower the resistance of the circuit the longer will the current continue to flow after the electromotive force is removed. In a large copper loop, for instance, of extremely low resistance a current will continue to flow for a long while just as water in a circular pipe will continue to flow if initially a rotary motion is imparted to it. The time required for the complete decay of current may be in some circuits very long.

Suppose that in some remote time in the history of the earth an electric current was

A bar of iron rapidly rotated as shown an electric current will continue flowing more than 10,000,000 years after the electromotive force which gave rise to it is removed.

started in the interior. This electric current would set up a magnetic field parallel to the earth's axis. A prominent physicist, H. Lamb, has computed that such a current in a sphere of the size of the earth and

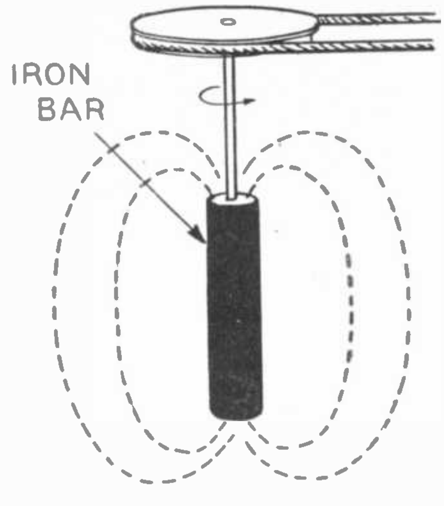
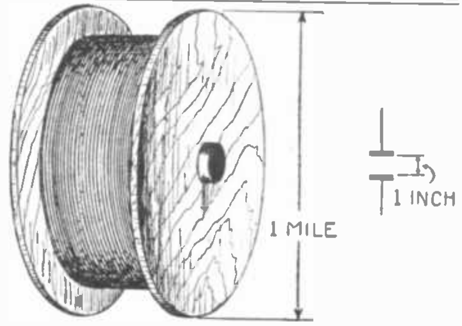


FIG. 4

A bar of magnet rapidly rotated as shown in the figure becomes magnetized by virtue of the gyroscopic forces exerted on the atoms.

having the conductivity of copper would require 10,000,000 years for the current to be reduced to one-third its original value after the electromotive force which started the current has ceased to exist. Imagine this electric current swinging around the earth for millions of years with only its own inertia for impelling power.

Such current may be quite small. It is computed that a current of .00000001 ampere per square centimeter on the surface at the equator, the current density being proportional to the distance from the axis of the earth, is sufficient to set up a magnetic field comparable to that of the earth.



A spool of copper wire, one mile in diameter, having one hundred million million turns, has a resistance equal to that of a cylinder of air one inch long and of the same cross-section as the wire.

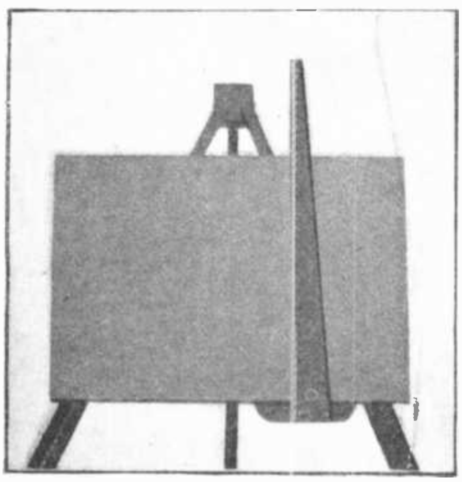
These are daring hypotheses and we are strongly attracted by them. But we still wait for the experimenter who will demonstrate the truths for which we vaguely grope with these abstract theories. The experimenter must be our final authority.

Magnetic T-Square

AN ingenious T-square is shown in the illustration given here. When a T-square is to be used in a vertical position on an inclined drawing-board, it will slip off unless it is placed with the stock on the upper edge of the board.

The objection to such an arrangement is that every time the square has to be shifted, the hand has to reach to the top of the board, which in itself is more or less inconvenient, and the sleeve brushing over the drawing, tends to dirty it.

These troubles in the instrument shown are obviated by the application of the permanent magnet. The board has a steel edge as its base, in itself a very excellent arrangement as giving a better true-edge to work from. The stock of the T-square is provided with a permanent magnet, so that when



The drawing-board shown above has a strip of iron along its lower edge; the stock or head of the T-square is provided with a permanent magnet on its inner edge, and the attraction between the iron and the magnet holds the T-square firmly in place even though the board may be nearly vertical.

the T-square is placed as shown, it is held firmly in position by magnetic attraction. Thus, when lines are to be drawn near the foot of the board, the upper part is not swept over by the artist's hand and arm, greatly to the benefit of the drawing, which inevitably suffers when such is done.

Preserving Cut Flowers

is a subject to be presented to the readers of *Science and Invention* for June. Prizes will be offered for the best method whereby cut flowers can be preserved the longest time. Start experimenting now and send your ideas and discoveries to the Editor of *Science and Invention*.

Articles to Appear in Science and Invention for May

Applied Chemistry—Prizes for the Best Methods By Which To Preserve Cut Flowers

How Much Light Will a Dollar Buy?
By Russell G. Harris, Ph.D.

How to Protect Yourself from Lightning Discharges
By H. W. Secor

Everyday Chemistry
By Raymond B. Wailes

Radio for the Novice, Elementary Circuits and Simple Descriptions
By M. Joffe

Shellac and Shellac Varnishes
By Dr. Ernest Bade

"Constructor" and "How To Make It" Departments

Hausdorff Super-Radio System
By Dr. Alfred Gradenwitz

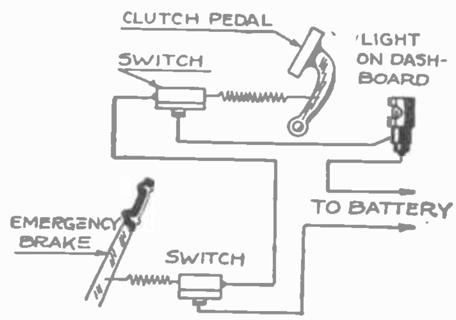
For rapid working on long lines, nothing can surpass an accurate T-square, and anything which conduces to its improvement will be welcomed by mechanical and architectural draftsmen. What we show is rather an interesting bit of perfecting, and calls upon

Emergency Brake Protection

VERY often when driving an automobile the emergency brake is set when the car is stopped and forgotten when the car is started again, thus wearing out the brake lining and putting a strain on the motor. It is the purpose of this article to give a simple device to notify the driver that the brake is set when he starts to move the car.

Two switches of special construction are needed, these being shown in the illustration. If the builder does not wish to go to the trouble of making these switches, they may be bought from almost any garage, as they are similar to the type used with the well-known "Stop" light. But it is a simple matter to make the switches, the parts being few.

A wood or fibre base is used, with a piece of sheet brass, tin or iron being cut and bent so as to form the body part—which is really for the purpose of forming a "slide" for the contact part. The sliding part may be of any suitable material, being of such size as to slide snugly through the body part. Attached to the base is a binding post, the part inside the body being quite flat. A piece of spring brass is so placed that when the sliding piece passes over it, it causes it to make contact with the binding post. Two springs are used with each of the switches as shown, these being for the purpose of pulling the sliding piece back into position each time and of keeping the heavy pull

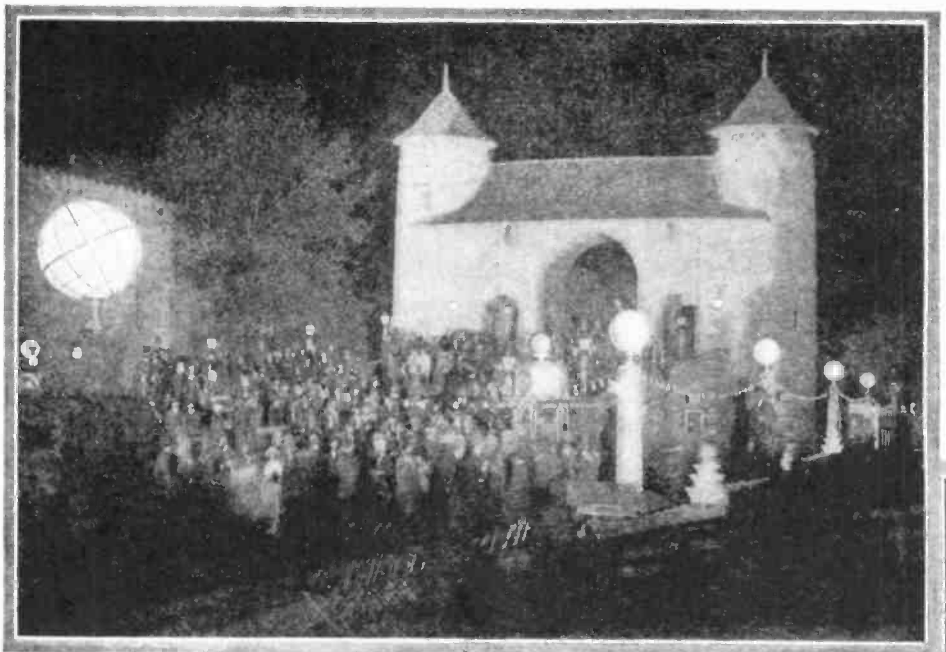


This is an arrangement for automatically releasing the brakes when an automobile is started. It is not at all infrequent for a careless motorist to drive a car for a considerable distance with the emergency brake set. Here pressing the clutch down release the brake and leaves the car ready to start.

off the switch. Connections are made as shown, a lamp being located on the dashboard to warn the driver. If the emergency brake is "set," the lamp will light when the driver uses the clutch to change the gears.

—*Contributed by Evermont Fisel.*

Flood Lighting at Wembley



The British Empire Exposition at Wembley, near London, England, made extensive use of flood lighting. Flood lighting achieves its effects by a powerful but diffused illumination; by placing projectors at considerable distances from the objects illuminated, an almost uniform lighting effect is readily obtained.

THE great British exposition at Wembley has closed, and the comments upon it have not always been favorable. The exhibition seems to have occasioned a considerable amount of displeasure.

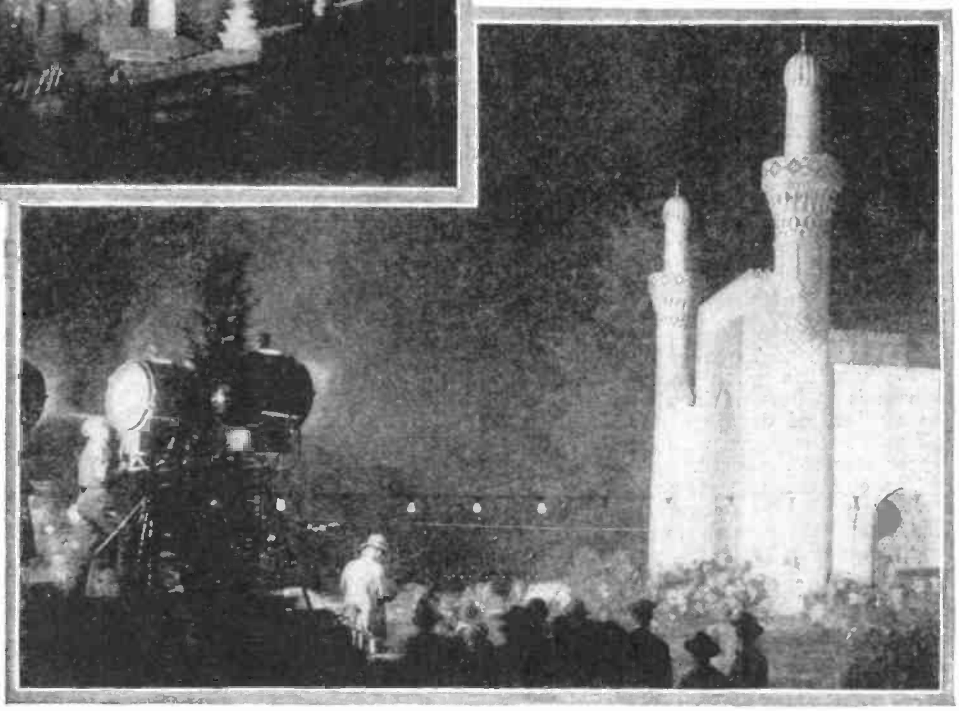
Above we illustrate some examples of flood lighting there. In the United States we are becoming more and more familiar with this system. Flood lighting is being applied very extensively; even in the suburbs numerous signs are to be seen of private businesses, and advertisements of cigarettes and the like, which after sundown are lighted by a series of lamps along their top, hidden from view, and whose rays literally flood the signs with light.

Sometimes another system is adopted and light is thrown upon a sign from projectors almost of the magic lantern type. If the sign is of any size, three or four projectors will suffice to cover its area.

The illumination of Niagara Falls by projection is also an example of flood lighting, where a flood of water and a flood of light provide material for a sort of pun.

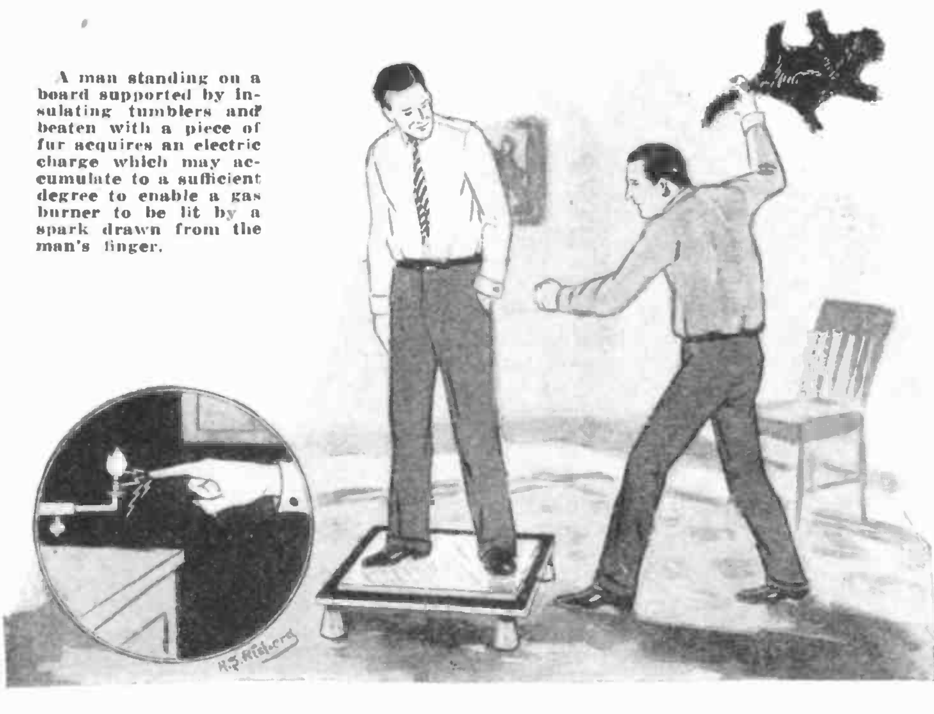
At Wembley the flood lighting is again by projection. While undoubtedly very beautiful, the impression conveyed by the reproduction is that it was not quite on a scale with such work as carried out in this country.

The photograph below shows some of the powerful projectors used in the flood lighting at the Wembley Exposition.



Experiment With Static

By CLYDE E. VOLKERS



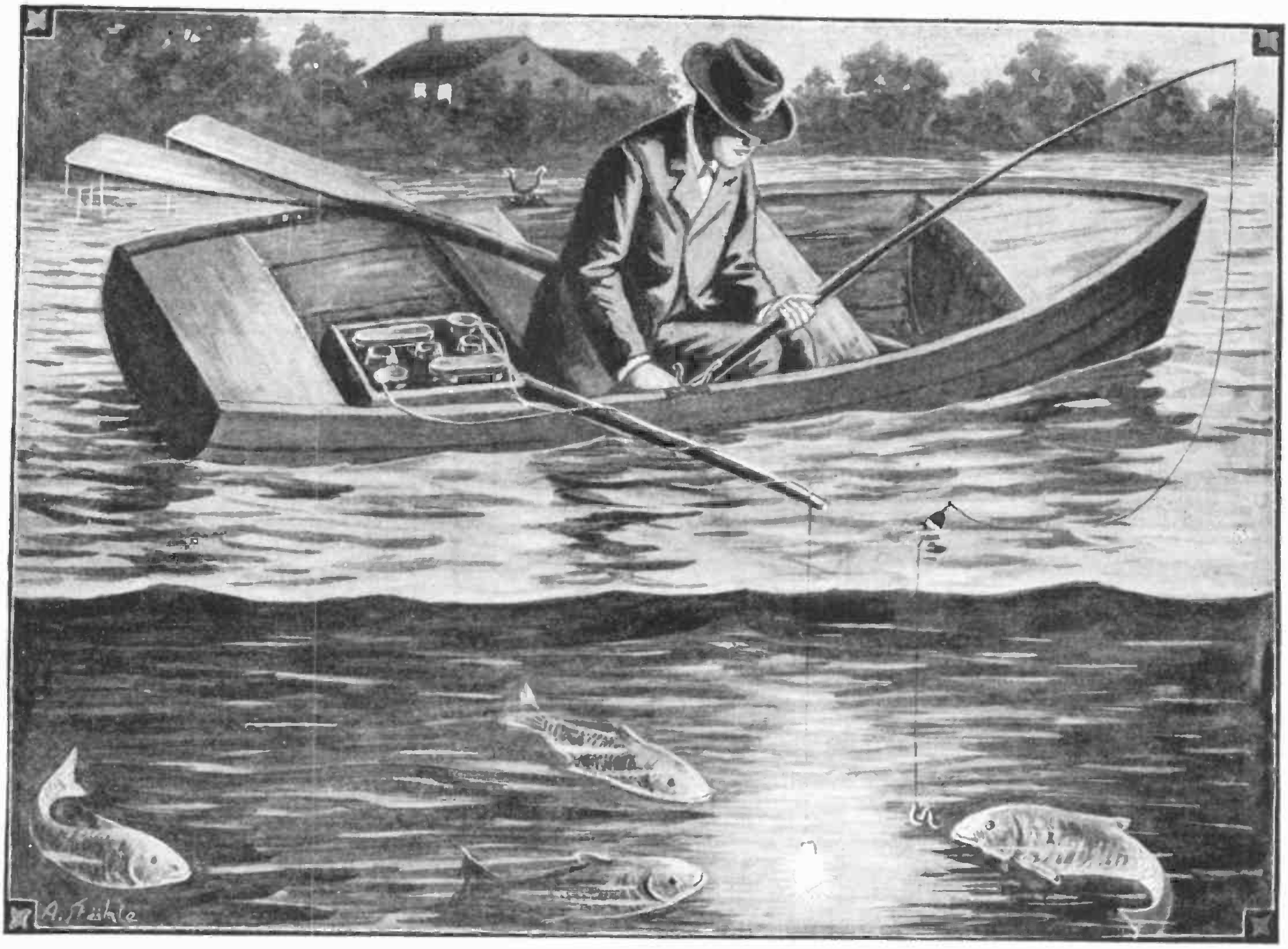
A man standing on a board supported by insulating tumblers and beaten with a piece of fur acquires an electric charge which may accumulate to a sufficient degree to enable a gas burner to be lit by a spark drawn from the man's finger.

THE principal apparatus to be used is very simple, and is constructed as shown in the diagram. Some person stands upon this insulated stool and submits to a severe whipping or flogging (which is entirely painless) with a cat skin. (Nor is it the writer's purpose to carry on a campaign against the feline world.) A heavy piece of flannel will give results, but the fur is better.

If the finger is now pointed to the tip of an unlighted burner out of which the gas is flowing, a spark will jump to the metal igniting the gas. The body must be recharged by another flogging in order to produce another such spark. Should the finger or any part of the skin of the "charged" person be touched by another, both will feel a tingling, as a spark leaps from one to the other. Best results are obtained in this experiment on days when the air is very dry.

Many of our readers are familiar with a simpler version of this experiment, when, walking with a shuffling motion over the carpet, the person becomes so charged that a spark can be produced by his touching a pipe or gas-burner.

Fish Attractor



Our illustration shows a reliable method of attracting fish by means of an electric light. A lamp suspended near the hook attracts the fish by its brilliance. On a motor boat current can be drawn from the generator instead of from a storage battery.

THIS fish attractor, if made correctly, an easy thing to do, will prove very successful as it draws the fish by curiosity and the natural attraction that light has in a dark place. It is not only based on sound theory, but has been found practical in two cases.

The first of these cases presents its use during several thousand years—*i. e.*, by Mother Nature. At the bottom of the ocean, where things are very dark, some fish are naturally equipped with glowing tentacles and some of the fish so equipped use this light to attract fish, which they feed on. The second case is more recent and is that of my father who used this, also with great success.

Merely take a long drop cord with an electric light at its end and attach a wire guard, such as is used in garages, etc. Around the metal base of the light, wind waterproof gummed tape so as to prevent short circuits. The ordinary electrician's house wire has rubber covering already. The wire guard is to prevent scum from accumulating, and has been found necessary.

In using this, wait until it has become dark, then lower the lighted lamp into the water from the shore or from a rowboat. In this case storage batteries are usually used, the lights being small, but on an electrically lighted motorboat the generator may be directly connected. On a motorboat, if desirous of netting the fish, trail the light, and, going in circles, come up upon the rear of the fish.

If the user does not wish to catch fish, the contrivance is good for watching them.

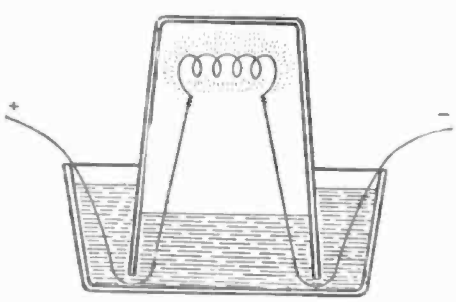
Contributed by EDGAR WELCH.

Early Incandescent Lamp

THE illustration shows one of the earliest attempts at the incandescent lamp. It was the invention of Grove, celebrated for his battery.

He had succeeded in getting a strong current which was not interfered with by polarization, and undertook to apply it to lighting by incandescence. The lamp which he used is shown here and as is evident is of the simplest possible description.

A spiral of platinum wire was mounted at the end of two insulating wires and was covered with a glass vessel as shown; this was inverted, bell-glass fashion, into one of larger diameter, and water was poured in to seal off the interior. The idea was to prevent cooling of the platinum wire by cutting off all circulation of the atmosphere, although the air within the vessel would be in constant motion and would cool the wire to some extent.



The diagram shows one of the first incandescent lamps. A platinum wire within an inverted tumbler was heated to incandescence by an electric current. The wire was inclosed in the tumbler to prevent circulation of the atmosphere around it.

Grove described the experiment as giving an intense light.

Referring to the cut it will be seen that the heat of the wire has expanded the air, and depressed the level of the water in the inverted glass.

The work of Grove was in development of the chemically depolarized battery. He used nitric acid to oxidize the hydrogen going to the platinum plate of his couple. The result was that nitric oxide was evolved and the battery had to be used in a ventilated room and at the best was an unpleasant neighbor.

EXPERIMENTAL RADIO

CONDUCTED BY ABNER J. GELULA

How To Make a Paper Disc Loud Speaker

By James Farnworth, Liverpool England

THIS loud speaker is the invention of a Frenchman, Dr. Luminir. It is manufactured in England on a commercial scale and is within the reach of every radio experimenter, as it costs but a few dollars to make.

The operation is simple; the essential parts consist merely of a large pleated stiff paper diaphram actuated by an ordinary headphone or loud speaker unit. The results are quite satisfactory; it is equal to the average loud speaker in volume, and superior to all horn type loud speakers in tone quality. All the overtones and harmonics are reproduced without distortion, and the lower notes of the musical scale, where many other loud speakers fail, sound especially well. It is an ideal loud speaker and can be made very artistic in appearance, as the illustrations show.

When the paper has been folded in pleat fashion, two ends are pasted together, forming the above cone-shaped object. It might be found advisable to iron each pleat, so as to increase the strength.

HERE is a real worthwhile loud speaker that every experimenter can build at very little cost.

Constructed in our laboratory, it is the first one we have ever found to be free from the blasting effect which is now so prevalent in all horn type speakers.

We recommended this disc loud speaker to our readers, and trust to hear from those who have built it.

—EDITOR.

Constructing the Speaker

The writer has experimented with various kinds of paper including parchment and has found parchment substitute a heavy hand-rolled paper the best. This can be obtained at many stationers for a few cents a sheet. If not long enough two pieces can be joined together.

Experiments with various sizes of frames from 8 inches to 18 inches in diameter showed that a 12-inch one is the best.

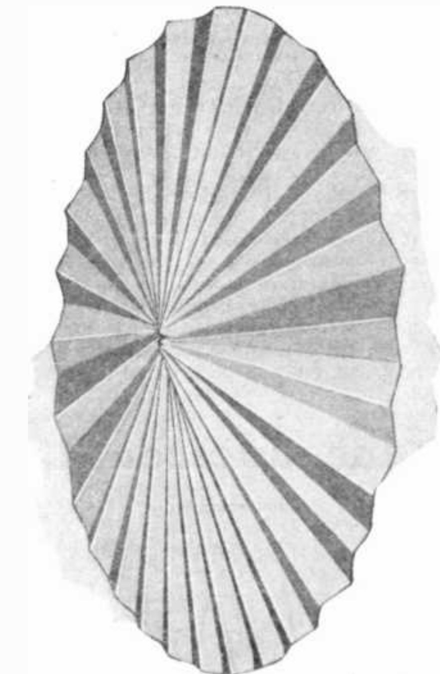
Materials necessary for making this type of loud speaker:

- 1 Adjustable "Rico Melotone" phone unit.
- 1 Embroidery frame, 12 inches in diameter.
- 1 Sheet of parchment substitute, 39½-inch by 6-inches.
- 1 Cork ¼-inch in diameter by ½-inch long.
- 1 Piece of copper bus bar wire, 3-inch long.
- 1 Piece of wood 12 x 1½ x ¾-inch.
- 2 Brass angles.

The Pleated Paper Disc

The parchment substitute should first be treated with a transparent lacquer. This can be obtained at any paint store. It is the kind used for lacquering brass work. The lacquer should be applied to both sides of the paper and one coat will be sufficient. This helps to waterproof the paper and make it a little thicker.

Rule lines down the width of the paper one-half inch apart, as shown. One-half inch is left over for joining. Now pleat the paper in half-inch pleats on the ruled lines so that it will look something like a fan closed up, be very careful in making the pleats or when the circle is formed it will not form to shape. When the pleats are made, bring the ends together and lap them over one-half inch and glue with liquid glue, forming a corrugated cylinder. Place something heavy on the joint until it sets.



By the palm of the hand the cone-shaped form is pressed into shape and becomes a flat disc as shown above. The wooden hoops secure the outside while the center is pasted to a cork.

The next operation is to form the paper into a disc. Put one end of the cylinder on the table and hold the other end with the left hand. Spread out the bottom end on the table and with the left hand press down on the top and the paper will spread out in the form of a radially pleated disc. When released, the center will rise up and leave a hole in the middle.

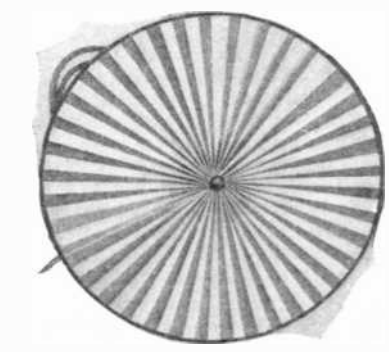
Smear a fair amount of the liquid glue on the center of the pleats. Insert the cork in the center hole and press the whole flat down on the table. The edges of the paper pleats will then bite into the cork if properly made. Lay the finished disc on a flat table with the weight on the center. The best way to do this is to place a cup over the cork and place a heavy book on the cup. It should be left to stand for several hours until the glue is fairly dry.

The Frame

Procure an embroidery frame 12 inches in diameter at an embroidery store. The frame consists of two wooden rings, one fitting inside the other. Place the paper disc or fan on the smaller ring. The paper will lap over about ¼-inch all around. Care should be taken to see that it does not lap over more at one side than the other, otherwise the cork will not be in the center. Place the larger ring on the top of the disc, and press down into place. The lap-over of the edges should now be between the two rings to form something like a tambourine. Two pairs of hands are better than one when doing this, for it will be found that when you press one end, the other will come up. Now glue a thin fibre or ebonite disc on the inside end of the cork. The reason for doing this is that the fibre is harder than the cork and the bus bar wire soldered to the diaphragm of the phone unit that is to bear up on it will not bore into the fibre as it would into the cork. Another way is to push the bus bar wire through the cork and let it project about ⅛-inch on the other side. It is then tightly sealed to the cork with sealing wax, glue or shellac.

The Phone Unit

Any headphone can be used, preference being given to the ones in which the pole pieces can be adjusted. Loud speaker phone units or phonograph attachments are ideal. The one shown in the photographic views

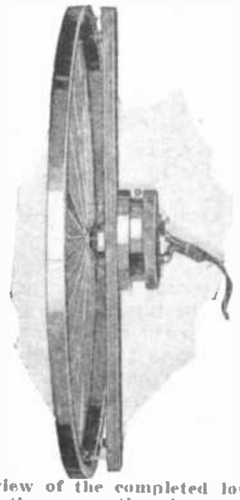


The rim has been placed around the pleated form and the center indicates where the phone connects to the paper disc by a bus bar armature.

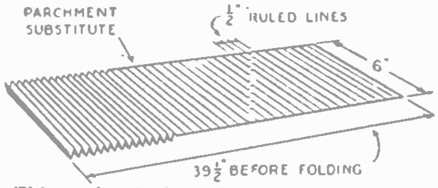
A Paper-Disc Loud Speaker

(Continued from preceding page)

gave excellent results. This is the "Rico Melotone" Phone Unit. The cap should be unscrewed and the bus bar wire soldered to the center of the diaphragm as shown. Be sure it is in the exact center. This particular phone unit has a metal cap Two holes were drilled through this cap for No. 6



A side view of the completed loud speaker. Note that the supporting brace upon which the phone unit rests is in the exact center of the paper disc.

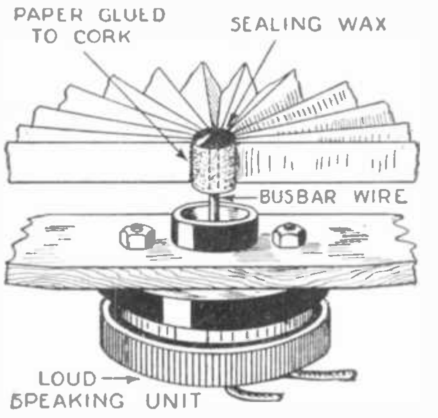


Thirty-nine inches of paper are spread out on a flat surface and ruled off by half-inch lines. Pleat the paper by following the lines.

screws and the screws fastened as shown. The cap was then re-screwed on the phone unit.

Assembling

Before assembling a wooden support should be drilled as shown in the detail drawing. This drilling fits the "Melotone" loud speaker unit and will no doubt have to be changed if another type of phone unit is used. The wooden support is fastened to the wooden rings on the diaphragm with two brass angles as shown. These angles can be easily made out of pieces of brass. They should be mounted accurately on the wooden rings so that when assembled the wire soldered to the diaphragm will come exactly at the center of the cork. If the fibre disc is glued to the cork, the wire should be cut off so that it will just press lightly on this



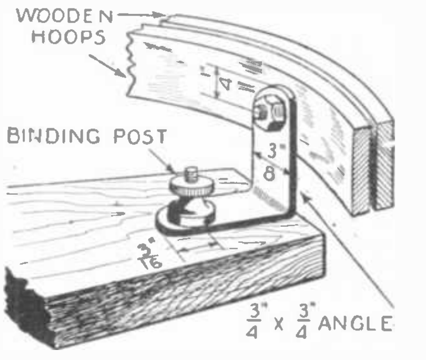
The paper cone is now pasted upon the cork center. The bus bar leading from the diaphragm of the phone to the cone must be in the exact center. Sealing wax will secure the bus bar armature.

disc when the phone unit is screwed to the wooden support. In the other construction mentioned, the wire should pass through the cork and be securely attached with sealing wax on the front as described.

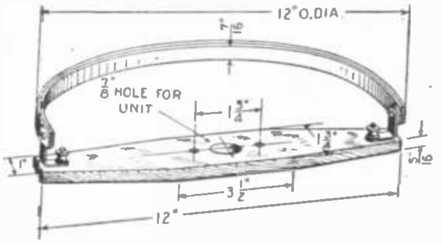
The phone unit should be connected to the radio set in the usual way. When a station is tuned in, the phone unit should be adjusted for best results. A very close adjustment to the diaphragm is possible with this speaker and the signals will be very loud and clear. They will not have the blasting effect produced by the horn type speaker. To enhance the artistic effect the speaker may be mounted on a bronze statue as shown in the illustrations and on our front cover. Similar statues may be obtained from most art or novelty stores, or attractive lamp bases may be used. The base should preferably be of heavy metal so that the speaker will not be top heavy. The experimenter can easily mount the speaker on to the metal base or statue.

Of course, the paper disc can be lacquered in any color to suit the taste. Gold or silver bronze may also be used with excellent results.

As shown on the front cover of this issue, the loud speaker may be mounted so as to compose a piece of statuary near the set. This will produce a unique effect, adding to the beauty of the speaker. The set may be



A detailed drawing of how the phone unit board is connected to the hoops supporting the pleated disc. The pleated paper is held by the pressure of the two hoops. It is found advisable, so as to doubly secure pleated discs to glue the paper in the hoops before pressure is exerted by the hoops themselves.



A more detailed drawing of the hoop and baseboard system of the paper disc loud speaker. For the sake of clearness, half of the hoop has been removed.

operated at a distance from the loud speaker. For instance, the outfit may be placed in the living room or "den" and the loud speaker at any part of the house where convenient.

This loud speaker has many advantages over the horn type. There are no "rattling" or "sizzling" noises. In fact, the average set noises are not as powerfully reproduced, in comparison with the signal, as in the loud speaker. Even static discharges are not noticed as much when heard through this type of loud speaker.

A Wave-Meter for Harmonics

The Bureau of Standards uses the harmonics of a separate oscillator (of known wave-length) in plotting the complete scale. Most experimenters avoid this method because they think that it is complicated or involves extra apparatus. In reality it is simple and those who have one step of audio amplification are well fitted for the work.

The separate oscillator is made from the amplifier by connecting a coil and condenser in the place of the secondary of the transformer, and by plugging a tickler into the phone jack.

Plug the phones in the detector circuit and tune in some station of known wave-length as KDKA on 326. Adjust the oscillator to the same wave by the "zero beat" method. Then tune in the harmonics of the oscillator, calibrating the wavemeter by the click method at each.

Weather from Static

It is well known in maritime and agricultural circles that static may be relied upon to tell the sailor or farmer almost exactly what the weather conditions will be as far in advance as 24 hours. The following interpretation of the various types of static discharges may be relied upon as being the results of a scientific observation and study of static as a weather forecaster.

There are six specific conditions to be observed in the study of static, as the following descriptions will show:

(1) Violent intermittent rumblings of static heard in the phones of a radio receiver indicate an approaching shower. If the rumbling sounds seem to increase in intensity, the storm is drawing nearer the vicinity of the receiving station, and *vice versa.*

(2) A hail storm in the vicinity of the receiver will make its approach known to the radio operator by a form of static resembling a low whistling sound.

(3) Brief cracklings, well spaced and rather weak in intensity, usually precede a temperature rise, such as a spring thaw.

(4) If the wind is about to shift its direction, static discharges will be more evident on low wave-lengths. This type of static may be compared to (1).

(5) Numerous rumblings, frequently accompanied by bursts of grinding discharges of heavy intensity, often burning out detector points, indicate great barometric depressions and are the forerunners of tempests and storms.

(6) The approach of rain, snow or fog, by increasing the conductivity of the air as well as of the earth, is favorable to radio communication. Little or no static will be heard during weather conditions as above outlined.

QRN, OM?

By Abner J. Gelula

THE dream of every experimenter is to eliminate the greatest of all radio evils—static. Many very able electrical and radio engineers have tried their hand at the elimination of atmospheric disturbances, with varying results.

It seems to be a popular belief that for the three summer months radio must be abandoned. Anyone who has listened to the summer broadcasting programs will tell you that they have a tendency to be even superior to those given in the winter. It is comparatively seldom, on the greater portion of the North American continent, that summer atmospherics are strong enough to interfere, seriously, with average reception. Undue publicity has been given this subject and the newer radio devotees have come to the conclusion that summer radio must be unbearable.

Older radio men will tell you that some of the worst static conditions have occurred during the winter months, and conversely some of the best of radio reception has been accomplished during summer months.

We all know that, during heavy disturbances, by removing the aerial lead, the atmospheric trouble greatly decreases. Reception, at this time, is accomplished practically wholly through the ground system. The loop aerial, the indoor aerial, and the double ground system all go a long ways toward the elimination of static.

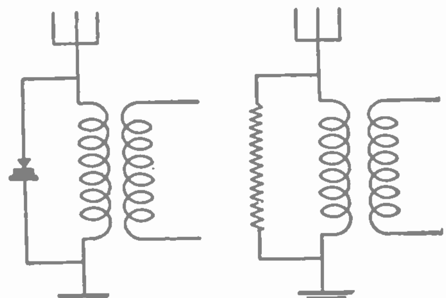


FIG. 1

A crystal or resistance of about two megohms (a variable grid leak would be ideal) across the aerial and ground eliminates light static discharges quite effectively.

Fig. 1 indicates how a crystal or resistance connected across the aerial and ground may be used as a partial eliminator of static. The use of the resonance coil across the aerial and ground greatly facilitates the control of all natural disturbances. A coil of this type may be easily built by the radio man who likes to "build his own." The coil is wound on a three- or four-inch form, 400 turns of No. 16 D.C.C. wire. Fig. 2 clearly shows the resonance coil complete, with the metal slider used to determine the proper point of resonance.

As stated above, the elimination of the aerial increases signal strength over static. Fig. 3 shows a good aerial-less receiving circuit. The input coil L_1 is composed of 80 turns wound on a 3½-inch form, tapped every eighth turn. The tickler is inductively coupled to L_1, 60 turns on a standard rotor form. Wind both coils with No. 24 D.C.C. wire. It is very important, when discarding the aerial entirely, that the ground system be particularly good.

An instrument was brought out about the middle of 1920 in which, by an acoustic system, the tone of the static was materially

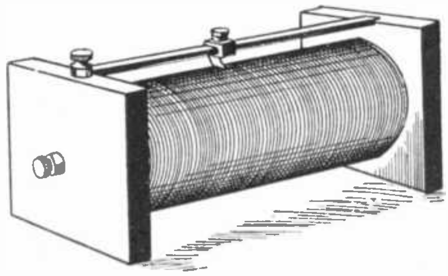


FIG. 2

A resonance coil, as shown above, connected across the primary coil, enables you to vary the intensity of the incoming static charges. In appearance it is similar to a tuning coil but contains many more turns.

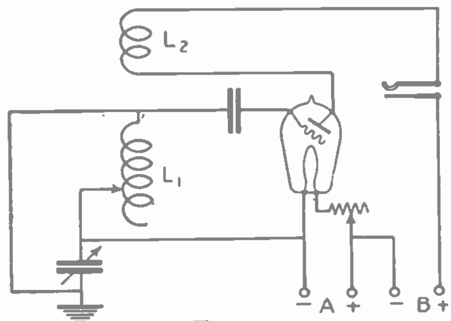


FIG. 3

You have no doubt noticed that by disconnecting the aerial, static decreases materially. This aerialless circuit it is very efficient.

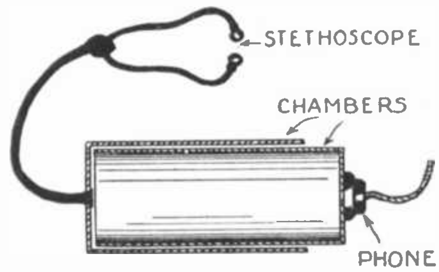
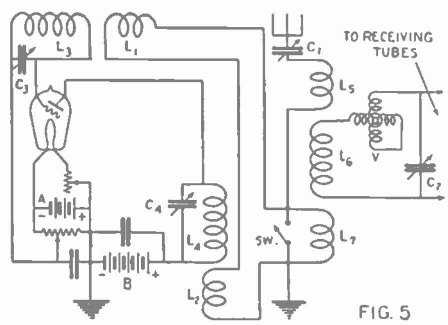


FIG. 4

A patent has been granted the above "static eliminator." Although it does not exactly eliminate the static, it changes the tone so that signals may be copied with greater ease.



A good circuit for the elimination of static. L1, 5 to 10 turns, two-inch diameter. L2, 50 to 75 turns honeycomb. L3, 60 turns, three-inch diameter. L4, 35 turns, three-inch diameter. L5, eight turns, L6, 50 turns, L7, 10 turns wound on one form, three-inch diameter. C1, 43-plate condenser; C2, 17-plate condenser; C3, 17-plate condenser; C4, 23-plate condenser, all variable.

changed. Instead of the heavy crashing or crackling sounds, the disturbance was changed to a bell tone. The apparatus was connected to the output of the receiving circuit, and, after passing through a cylindrical form whose length was variable, the signal was received by a stethoscopic arrangement. The radio man who is handy with tools will find it comparatively simple to build an instrument of this type. Two metal cylinders are secured, one of the cylinders smaller than the other so that it will slip tightly within the larger. Fig. 4 gives the constructional details for an instrument of this type. A loud speaking phone unit, such as the Baldwin, transmits the signal by sound through the chamber.

Reflex circuits using a crystal detector seem to do much towards solving static elimination. The crystal used as a detector, seems always to cut down the static signal ratio. Fig. 5 shows a recently devised static eliminator which promises much in properly controlling atmospheric conditions.

The underground antenna, although not as popular with the radio man as the standard outdoor aerial, seems to aid in cutting down atmospherics.

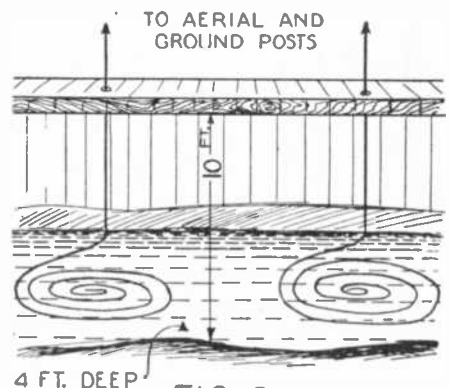


FIG. 6

The underground or underwater antenna as shown above, although not quite as sensitive as the sky antenna, is very effective as an eliminator of atmospheric.

The underground antenna is easily made by burying the average aerial length of wire about three or four inches beneath the surface of the earth. The wire for this aerial must be well insulated and of No. 14 B. & S. gauge. The ground is used in the ordinary way; the underground antenna taking the place of the sky antenna.

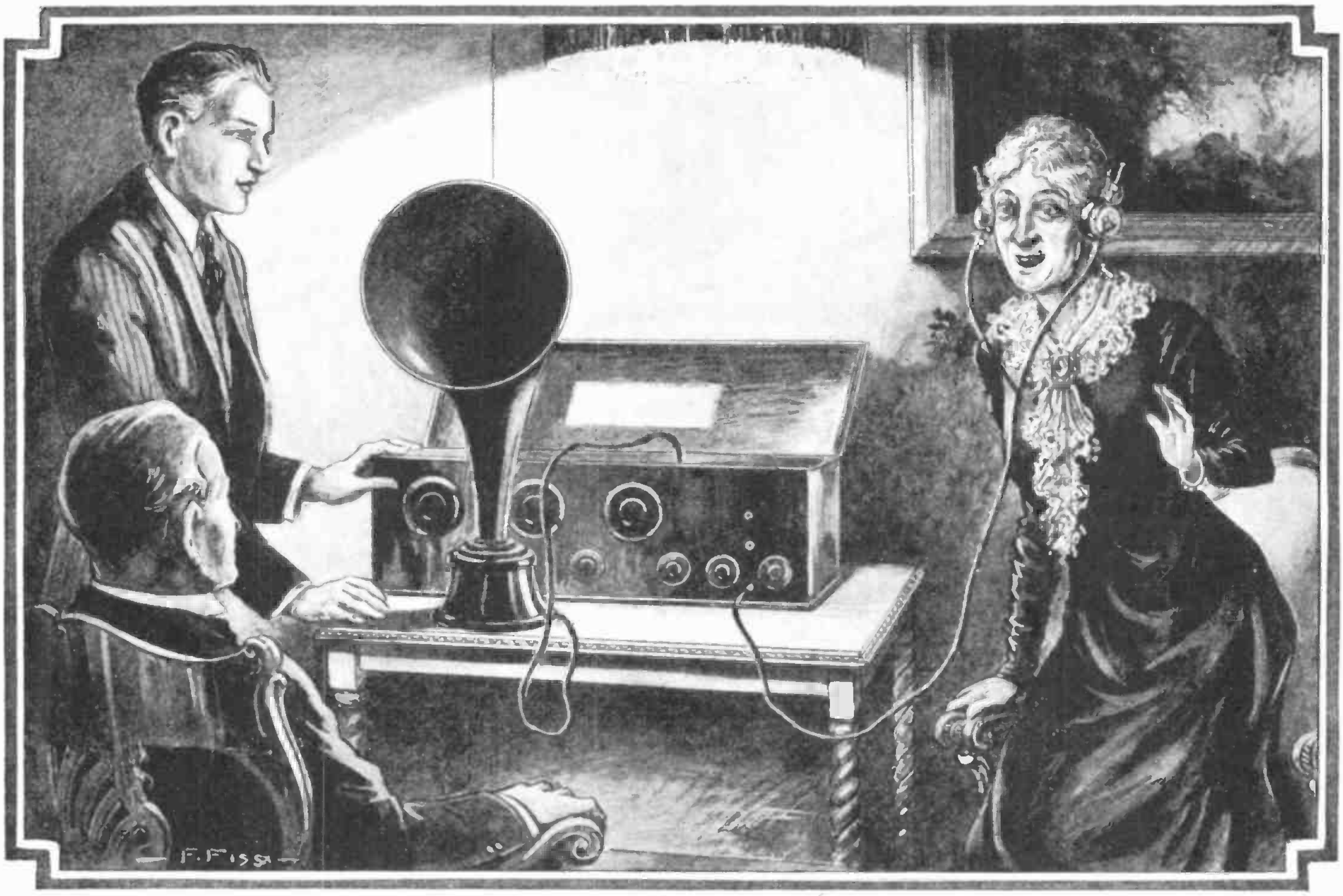
Another system of reception by the underground antenna system is by the use of two coils of wire placed on the bottom of a river or lake. Obviously, it will be necessary to use a two-stage audio frequency amplifier in connection with a good receiver if maximum results are to be obtained. Fig. 6 explains graphically how an underwater aerial may be used for both aerial and ground systems.

Certainly, the radio man or electrical engineer who eliminates static will find the world wearing a beaten path to his door, and proclaiming him a great public benefactor. It is the earnest wish of the writer that this article will give a better insight to the radio man experimenting with static eliminators and present a general review of what has been done in the past toward solving the atmospherics elimination problem.

Audio in Set Makes Deaf Hear

System May Be Used Also for Detectograph

By C. Edwin Keagy



Radio has been put to a new use. It is comparatively simple to help the deaf to hear by a simple use of the audio amplification in your set. If you have a detector jack in the last stage audio jack, matters are greatly simplified. If the detector jack is of the double circuit variety, it will be necessary to connect the primary of the first audio frequency transformer to the output of the detector. Plug the loud speaker into the detector jack and the phone into the last audio. You have but to speak gently into the loud speaker and the volume will be tremendous in the phones.

ALMOST every builder of a radio set knows how to connect two headphones in series with several dry cells and make one a receiver, and one a transmitter. The original Bell telephone employed this system. Here is another method by which anyone can achieve the same results and with a much greater degree of success by merely using the amplifiers of their loud speaker radio set.

First turn out the filaments of your radio frequency and detector tubes—you will not need these. Then connect the terminals from the loud speaker to the primary binding posts of the first audio transformer. Plug the headphones in on the second stage and now light the filaments of the audio amplifier tubes. Upon wearing the headphones you will hear a myriad of sounds, all coming from other persons moving about the room, even from objects being laid down and moved about. This indicates that the loud speaker is working as a microphone. Have someone stand about twenty-five feet from the loud speaker and talk in an ordinary tone of voice. You will hear every word clearly and distinctly. Do not speak in a loud voice near the loud speaker as there is danger of injuring your ear drums. The loud speaker may be concealed in another room or on another floor and the conversation of anyone within twenty-five to fifty feet may be clearly heard.

Now let us reverse the procedure and place the headphones across the primary of the first audio transformer and plug the loud speaker in the second stage jack. Then speak into the headphones and your voice will come out of the loud speaker amplified many times.

Many people have their radio set on the second floor and the loud speaker wired to the parlor or sitting room on the first floor. But when operating their set from the second floor they cannot tell how good the volume and clarity of the signals are on the first floor. By using the above-mentioned connections you may speak into the headphones and ask those on the first floor what the quality of the reception is. Tell them to remain where they are and speak in an ordinary tone of voice and you will hear them. Then reverse the connections (that is, connect the loud speaker to the primary of the first transformer and the phones in the loud speaker jack), put on the phones and you will hear them plainly.

It goes without saying that those on the first floor will be greatly surprised when they hear your voice coming through the loud speaker, but they will be more so when they find that they too can converse with you by merely talking back into it.

Recently the author had an opportunity to put the aforementioned experiment to a real and more practical use. While visiting the home of a neighbor, an elderly lady who is quite deaf, stopped in for a few moments and I noticed that in speaking to her one had to actually shout to be heard. This was not so bad for a while until the elderly lady decided that she would put off another visit she had proposed for that evening and would remain with the people upon whom I was calling. At that, the members of the family looked at each other in dismay for they knew they were in for an evening of much loud talking and embarrassment.

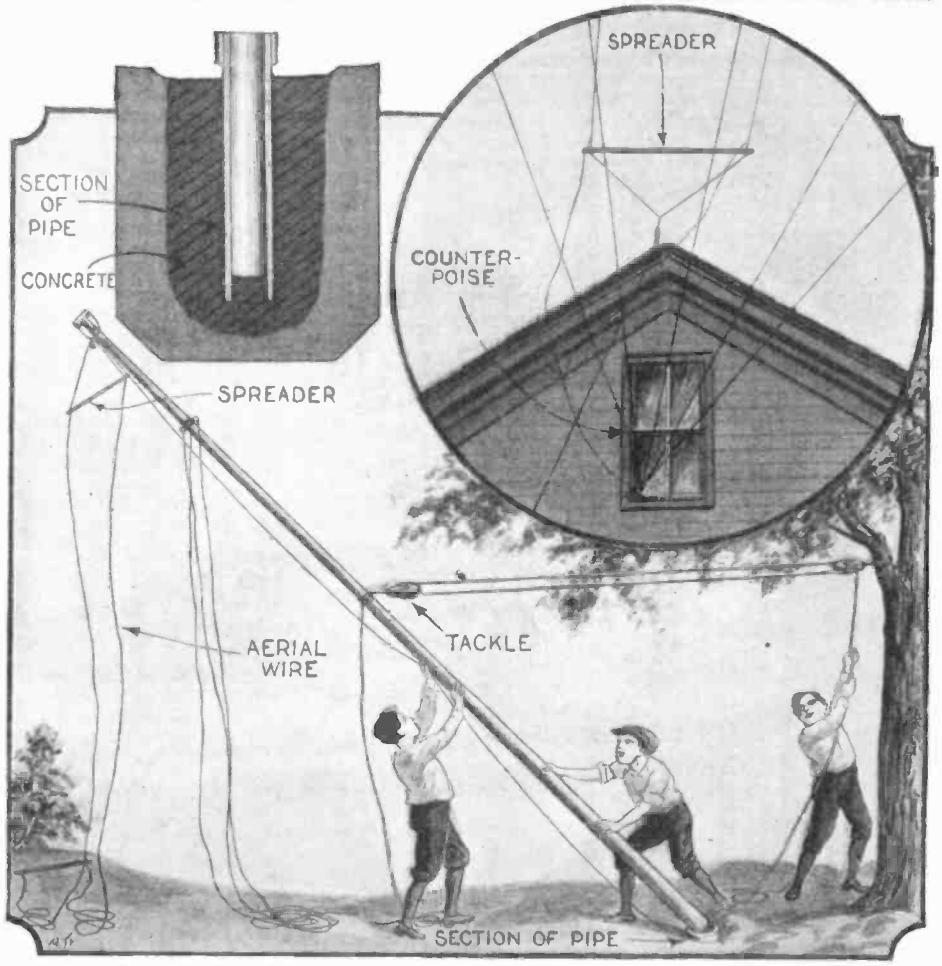
At this point an idea came to me that I thought would relieve the situation for the family and also prove more comfortable for the elderly lady. Accordingly, I asked her if she would mind moving over near the radio set. After getting her seated there in a comfortable chair I placed the headphone over her ears and adjusted them so as to be comfortable. Then I plugged the phones in the loud speaker jack and placed the terminals of the loud speaker across the primary of the first audio transformer. Turning to the loud speaker I said: "Do you hear me?" Well, the old lady nearly jumped out of her chair with surprise. Then I had members of the family who were sitting across the room, speak to her in an ordinary tone of voice, and she heard them clearly, every word. I cannot begin to tell you how pleased both the family and the old lady were at my device.

Getting On the Air

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

The Third of a Series of Articles Dealing With the Construction of a Short Wave Amateur Transmitting and Receiving Station Wherein the Erection of an Efficient Antenna and Counterpoise Are Discussed

IF you have constructed a radio receiving set such as described by the writer in the last issue of this magazine or have on hand any type of set capable of tuning to the shorter wave-length, that is, from about 70 to 200 meters, you are undoubtedly ready and anxious to start in transmitting, particularly if you have diligently studied the code and practiced so that you can receive messages at a creditable speed. However, before it is possible to install an efficient transmitter, an antenna of correct design must be erected. This work requires quite some time, particularly when only a few hours every week end are available. It is well to carefully consider the situation and make all your plans before you start to erect the mast and the antenna. This is presupposing that two convenient houses or a house and a tree are not available between which the antenna and counterpoise can be strung. In the majority of cases that the writer has come across, only a house was available for attaching one end of the antenna to and it was absolutely necessary that a mast of some kind should be erected for fastening the other end of the aerial.



In erecting a high aerial, a good-sized iron pipe is ideal. To raise the pipe a system of tackle is necessary as well as the proper method for securing it after it is raised. The insert at the left indicates the drain pipe that is to secure the mast. The drain pipe is filled with concrete just before the pole enters the pipe. The mast must be guyed immediately so that the concrete will set firmly about the base of the mast. In transmission a counterpoise gives a greater range than the ground used by the average "ham"; it also enables sharper tuning.

Location

First, you will have to consider the position in which the mast is to be located. It should be so situated that, after the antenna is erected, it will not come in contact with any trees, houses or other grounded objects. The antenna should have a clear space and should not come within a few feet of any other object throughout its entire length. Also, the mast should be located so that an aerial approximately 50 feet long can be conveniently stretched between the top of it and the house. If this is not possible, and the mast must be further than 50 feet from the house, as was the case in the writer's situation, it will be necessary to break up the aerial with insulators so that the antenna proper will not be over this length. If too long an antenna is erected, it will be found that the capacity of the series condenser will be so small that there will be a very small transference of energy to the primary circuit of the transmitter and the results will not be all that may be desired. Therefore, keep your antenna length down to not more than 50 feet. With this length, a lead-in not over 15 feet long can be used with excellent results.

The Mast

The first thing to do, after selecting a location for the base of the mast, is to get together all of the materials necessary for its construction and for the antenna as well. The writer's mast consists of three lengths of iron pipe, each one approximately 18 feet long and successively 2⅜, 2 and 1⅝ inches in outside diameter. With these sizes of pipe it was found that they could be readily telescoped and fastened in position. Here an unforeseen situation arose. The writer did not have on hand the required tools for drilling holes in the pipes through which bolts could be fastened to hold the telescoped sections in position. Furthermore, such a procedure, while very good from a mechanical standpoint, entailed a considerable amount of work and therefore a makeshift method was used. The pipes were telescoped into each other for a distance of about 2 feet. Of course, in order to do this, they were laid out on the ground in a straight line. A distance of about 4 inches longer than the telescoped section was measured off from the upper end of the lower section and two dents made in the pipe with a 16-pound sledge hammer on opposite sides of the pipe. This effectively prevented the second section from slipping further into the lower section. The same procedure was used to keep the top section from slipping further into the second section.

The other materials that are necessary for the mast are a quantity of guy wire which may be No. 12 galvanized iron wire. A sufficient amount of this should be used to make up two sets of guy wires, each set consisting of three wires. One set should be long enough to reach from the top of the mast to a point at least 30 feet from the base. The other set should reach from the center of the mast to the same point on the ground. Convenient fence posts, if solid, make excellent anchors for guy wires. While the mast is lying on the ground, these guy wires should be fastened in place on the mast. A good method of fastening the top guy wires is to procure a T connection. This is to be screwed on to the end of the top section, whereupon the guy wires may be fastened through the horizontal part of the T. At this place, fasten the pulley also. A length of the material used for guy wires may be used for this purpose. After fastening all the guy wires to the mast, lay them out on the ground in the general direction in which they are run and place sufficient ⅜-inch manilla rope through the pulley so that each end will reach to the bottom of the mast. Knot these two ends together so that they cannot run out through the pulley.

Now at the point where the mast is to be erected, dig a hole about 3 feet deep by 1 foot in diameter. Insert therein a 3-foot length of cast iron soil pipe at least 5 inches in diameter and fill the hole with concrete. It is quite necessary that a good solid foundation be provided for the mast and this method will do just that. While placing the concrete around the soil pipe, place a layer about 3 inches deep in the bottom of that pipe for the base of the mast to rest upon.

The best way to raise a mast is by means of what is known as a jig pole. This consists of a 20-foot length of 2 x 4, solidly set in a hole in the ground about 15 feet away from the mast mounting. A block and tackle is fastened to the upper end of this jig pole and the tackle run to a point about half way up the mast and fastened there with a rope tied in such a manner that a pull on the loose end will release the knot. This is done so that the tackle may be removed from the mast after it is in position.

You will now be ready to raise the mast. Place the lower end over the soil pipe and have one man stationed at that point to control the lower end. Another one must be in position at the foot of the jig pole to pull on the controlling rope of the block and tackle. A third party will be useful to steady the mast as it starts to go up. Then you will be ready to raise the mast. Pulling on the controlling rope will raise it off the ground, and the man at the foot should continually steady the mast with his hands

(Continued on page 457)

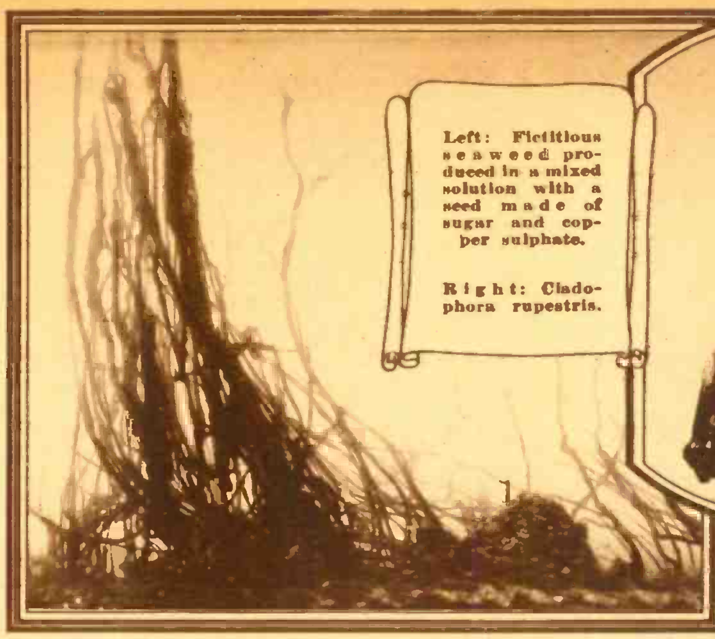
Chemical Vegetation

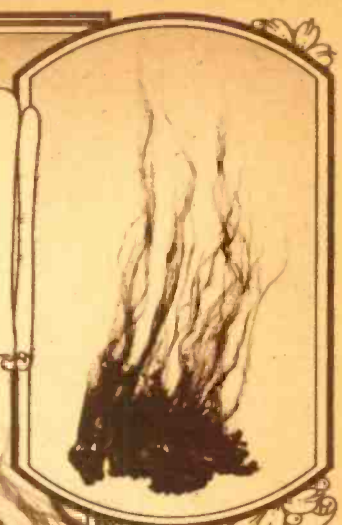
By Dr. E. Bade

IT is quite probable that if a simple chemical product would have the property of absorbing, from its surrounding medium, those substances necessary for growth, we would surely understand what life really is. But this is still a hidden secret of nature. Nevertheless, experiments are quietly conducted in many parts of the

(*Continued on page 479*)

True seaweeds found in shallow water resembling the chemical precipitations are also shown here. Note the appearance identical with that of the artificial seaweeds produced chemically in special solutions.





Left: Fictitious seaweed produced in a mixed solution with a seed made of sugar and copper sulphate.

Right: Cladophora rupestris.

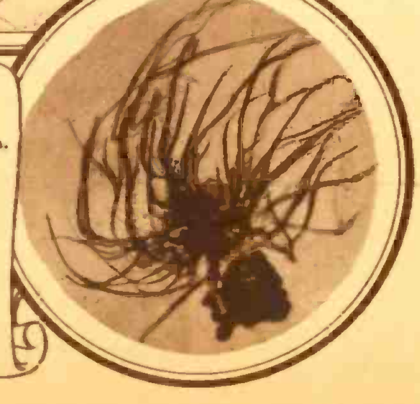
Microscopic animal-like structures produced with water glass, using a seed of ferrous chloride.

A cluster of Agardhiella tenera; another example is shown on the right side of the page.

Agardhiella tenera.

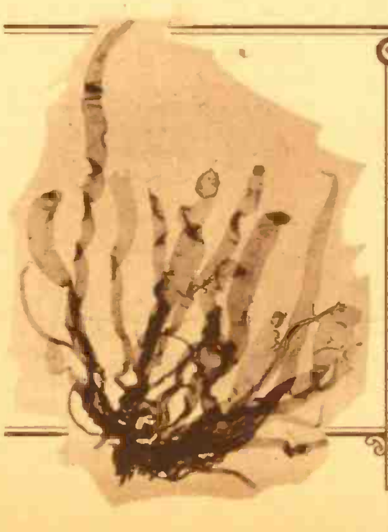
Precipitate produced in a dilute solution of potassium ferrocyanide using a seed of cupric chloride.

Above: Enteromorpha.

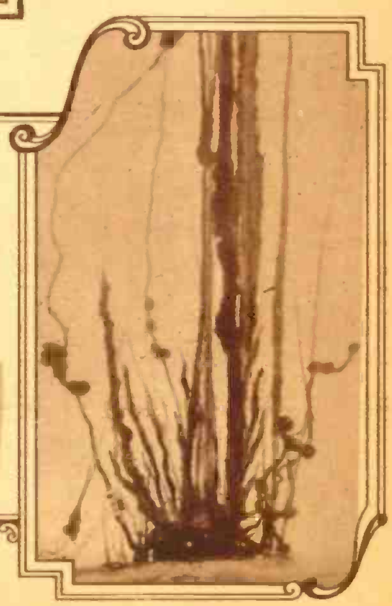


Right: A single precipitation produced by means of water glass and ferrous chloride, 60 times enlarged.

Below, right: Enteromorpha compressa.

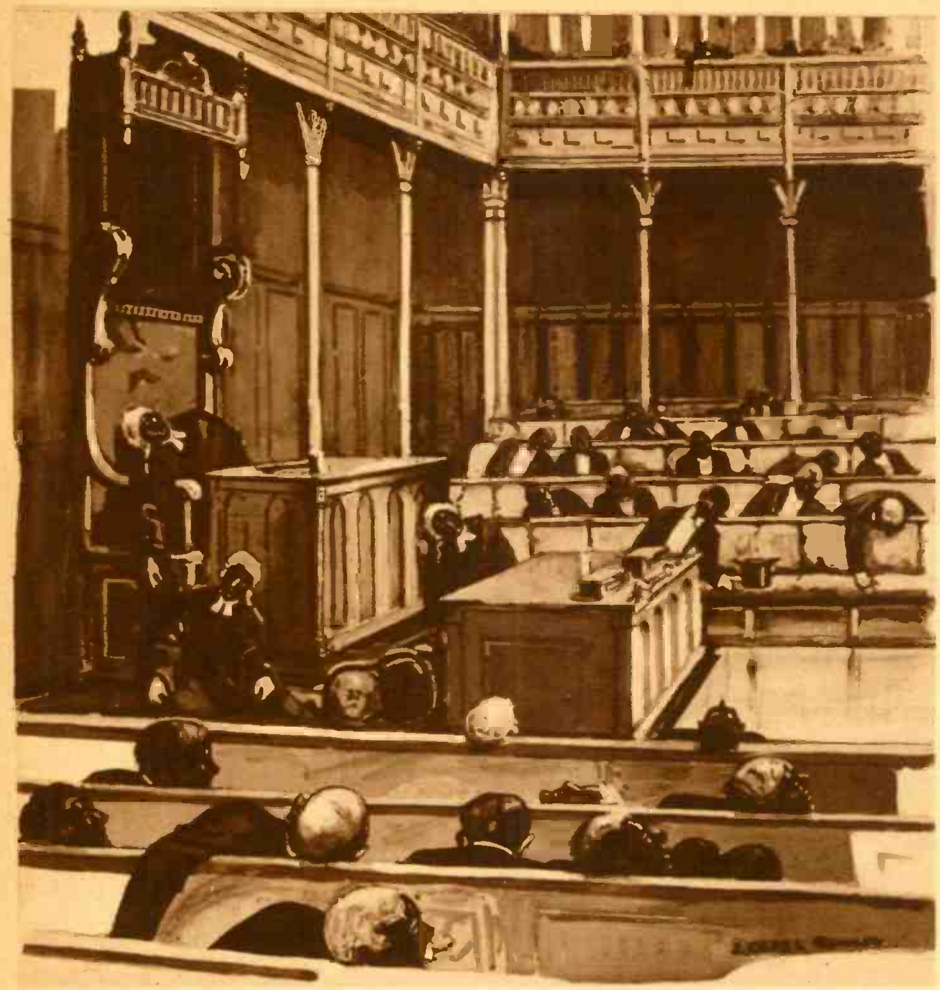


Below, extreme right: A precipitate produced in dilute water glass using a seed of ferrous chloride.



Ark of the Covenant

By VICTOR Mac CLURE



"He burst into a roar of laughter, shaking, shaking, until Lord Almeric and I sprang up in alarm. Soldiers have given way to hysterics in the midst of a great nervous strain before, and I thought the general had an attack. I don't know what Lord Almeric thought, but he evidently considered the laughter a little ill-timed.

"No, no! I'm all right, really—I'm not unstrung!" gasped Sir Thomas. "The raiders did gas the Commons this morning—and every man jack on the Treasury Bench woke up with his face blackened! Blackened, by George!—with burnt cork!"

[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 wakes him. Instinctively the son realized that something was wrong, and seeing that his father was in deadly earnest, no questions were asked, but with his roadster and airplane he undertook to rush him to the city.

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 lead cases.

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 without success tried to find out how the quantity of gasoline was taken from the Standard Oil station on land; they hear that there was a cabin in the air when the robbery was being perpetrated. Going out to sea, they find the Parnassic apparently abandoned and land upon her. 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. The personality of the young lady begins to have its effect on the male members 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 in the Merlin takes them to Louisville, where the New York raid has been duplicated. Next the Atlantic is crossed to Europe where raids have been perpetrated in several cities. The bank of England has been robbed and Scotland Yard is helpless.

At the Bank of England With a Scotland Yard Chief

We went along Old Broad Street, and there I found traces of the powdered glass, three splashes, opposite the robbed banks. I thought it would be a waste of time to do anything further in the way of investigation. I had seen enough to convince me that it was the Wall Street and *Parnassic* gang, or another allied in method. My next move, I thought, would be to get an ocean track chart.

On my return to the Bank, I found Lord Almeric closeted with a military-looking man, alert and keen of manner.

"This is Mr. James Boon, Sir Thomas," said Lord Almeric. "General Sir Thomas Basildon, Jimmy, chief of the Criminal Investigation Department."

We shook hands.

"I have wanted to meet you, Mr. Boon," said the newcomer kindly. "I have known your work for several years—and admired it."

"That's very kind of you, sir. Are you the General Basildon who was connected with the British Air Force?"

"I am."

"Then you have something in your old line here, Sir Thomas," said I. "I'm willing to bet you already have your air police out in full force, scouring the air toward the Atlantic."

Sir Thomas nodded slowly and looked at me keenly.

"You're the man who first propounded the theory that the American raids were carried out by aircraft?" he asked.

"Can't claim that amount of credit, sir. It was just the obvious sort of idea that must have come to a lot of people together. I said airship, because of certain difficulties of manœuvring, taking up the weight of the stolen stuff, the regular practice of stealing gasoline."

"Let me say at once that I agree with you, and that I have taken a very serious view of the matter as it might concern us here. I wanted our people to adopt the recent American plan of supplying gas-masks to all guards on banks, and to put up gas-proof glass observation cages at favorable points. That was your idea, too?" he broke off.

"No. The suggestion for that came from a friend of mine, Dan Lamont, sir."

"Ah, yes. Mr. Dan Lamont," said Sir Thomas. "Well, I wanted our people to adopt these measures, but they are slow to move—damnably slow! They were convinced that the raids were an American concern. The measures are being adopted, after prolonged discussion, but they come too late, as usual, to be of any service." He laughed grimly. "We shall probably have the masks and the cages ready by the time the raiders have been run to earth."

"If you think that, you will have your scouts out?"

"They have been in the air this last hour or so, Mr. Boon," replied Sir Thomas, with a smile. "I understand from Sir Almeric that you have been on the scene soon after each raid?"

"With the exception of the *Westbury*, yes."

"There are some points on which I should like the benefit of your experience, Mr. Boon——"

"Anything I can do, sir——"

He questioned me shrewdly, until I had covered the ground of the whole raids, down to the minutest detail. Then, when he had satisfied himself that he had exhausted all my information, he got Lord Almeric to have an ocean track chart found for us, and we pored over it together.

It took the Transatlantic Company's airships a net 60 hours from New York to London, but a less heavily-built machine might do it in 50-odd. Adding on the difference in time between the two cities brought the time occupied to about 60, gross. That is to say: if an airship with a cruising speed about one-thirty kilometers per hour had wanted to be over London just after midnight on the Friday, she would have had to leave her base on the American continent not later than midday on the Wednesday. But the chances were that, to escape observation, the departure in actual case had been made in the dark of the early Wednesday morning.

The Louisville raid happened on the Sunday night and Monday morning, and it was likely that the airship had made her base either in the dark of the Monday morning or on Monday night. Leaving Louisville about four after the raid, it would be six before she reached any likely base in the Alleghenies, and by that time the farm folk would be about on their morning chores. The vessel could hardly escape being seen in the light at six o'clock. This brought us back to the notion of a base at least 12 hour's flight from Louisville, and gave additional color to the theory of a base over the Canadian border, probably in some undeveloped district back of Ontario.

To berth an airship on the Monday evening, and to have her fitted out again for a raid across the Atlantic within 30-odd hours, was something of a feat. There was the unloading of the Louisville haul, the refilling of the balloonets with gas, the retuning of the engines, and the general tightening up and overhauling necessary for such an important voyage. If the raiders were using only one dirigible, she was a wonder of efficiency.

It was quite within possibility that they had two machines for their operations, and the three of us discussing the situation in Lord Almeric's room were not inclined to dismiss the idea idly, when we considered the daring which could conceive and carry out raids on such a wide radius, and the magnitude of the organization behind the conception. Indeed, it seemed not too far-fetched an idea that the organization operated from bases in both the Old World and the New, and that in imagining one solitary lair in Ontario we were seriously underestimating the power of this mysterious force.

Why Was Not All the Gold Taken?

There seemed to be neither rhyme nor reason in the operations. Of several millions of pounds sterling in gold lying in the Bank of England, the raiders had abstracted merely one, so Lord Almeric told us, and all the trouble that had been involved in forcing the three joint stock banks had not yet been rewarded by the finding of any gold; but in each of these banks there had been the same insensate destruction by acid of thousands of pounds' worth of bearer securities. It looked like the work of madmen, impish destructiveness and senseless expenditure of energy. Why trouble to force four banks when there was sufficient loot in the most important?

"It might have been," I suggested, "that they broke open the Broad Street Banks first, were disappointed of a haul from them, and destroyed the securities out of spleen, then came onto the Bank of England only to find that there was more gold here than they could get away with."

"I'm afraid, Jimmy," said Lord Almeric, "that that explanation will not serve. It is a matter of almost daily news how much gold is deposited in the Bank here. It is also common knowledge that the joint-stock banks since the war have kept no reserve of gold, but have had a working arrangement with us."

"These are not criminals in the ordinary sense," said Sir Thomas. "The distribution of the radium points to that, the care that has been exercised to preserve life in the raids. There is some idea, as you have said, Mr. Boon, underlying it all, and the future will probably show what the idea is. We may regard this raid as a demonstration of power, an attempt to bring chaos into the business world, to upset values—some cranky method of advertising an idea presently to be revealed. If I may be allowed to express what is merely an intuition on my part, I do not believe that these raiders value even the gold they have taken. They have marvelous power—marvelous! But the vulnerable point in any scheme of attack is its weakest link. That is in the air in this case. I cannot believe that the scheme of the raiders can be carried out with a dirigible. We have proved the vulnerability of the airship time and again, and it is on this point that we will get them. I shall not concern myself solely with looking for these criminals or cranks on solid earth. I will keep after them in the air, and, by God—get them, too! —if they are on my side of the globe!"

"Bully for you, General!" I couldn't help yelling, he spoke with such force. "I beg your pardon."

"Not at all," said he. "The best thing you can do is to get back to America at your quickest speed, and pitch into the authorities there. If the raiders are operating from Canada, until measures are taken to stop them, the whole of your wealthy cities around the Great Lakes are at their mercy—Chicago, Buffalo, Detroit—and the coastal cities, also—Boston, Philadelphia, Washington. Make them see what you and I see, that if this menace is to be scotched they will need aeroplanes, fighting aeroplanes that can climb to 5,000 meters and more. Make them understand that this is not any parochial question, or national, but that it is for the world to face and beat. For me, I shall strongly represent to our government that the Canadian authorities be asked to go over their territory with the minutest serach they can. And I will put the French police on their guard—and the Germans—the Germans——"

He broke off and eyed Lord Almeric queerly.

"No, my dear Basildon," said Lord Almeric. "I can believe much of them, but that they would leave so many millions of the gold they so badly want behind them—no."

"A blind?"

"Not they. They are incapable of the sacrifice."

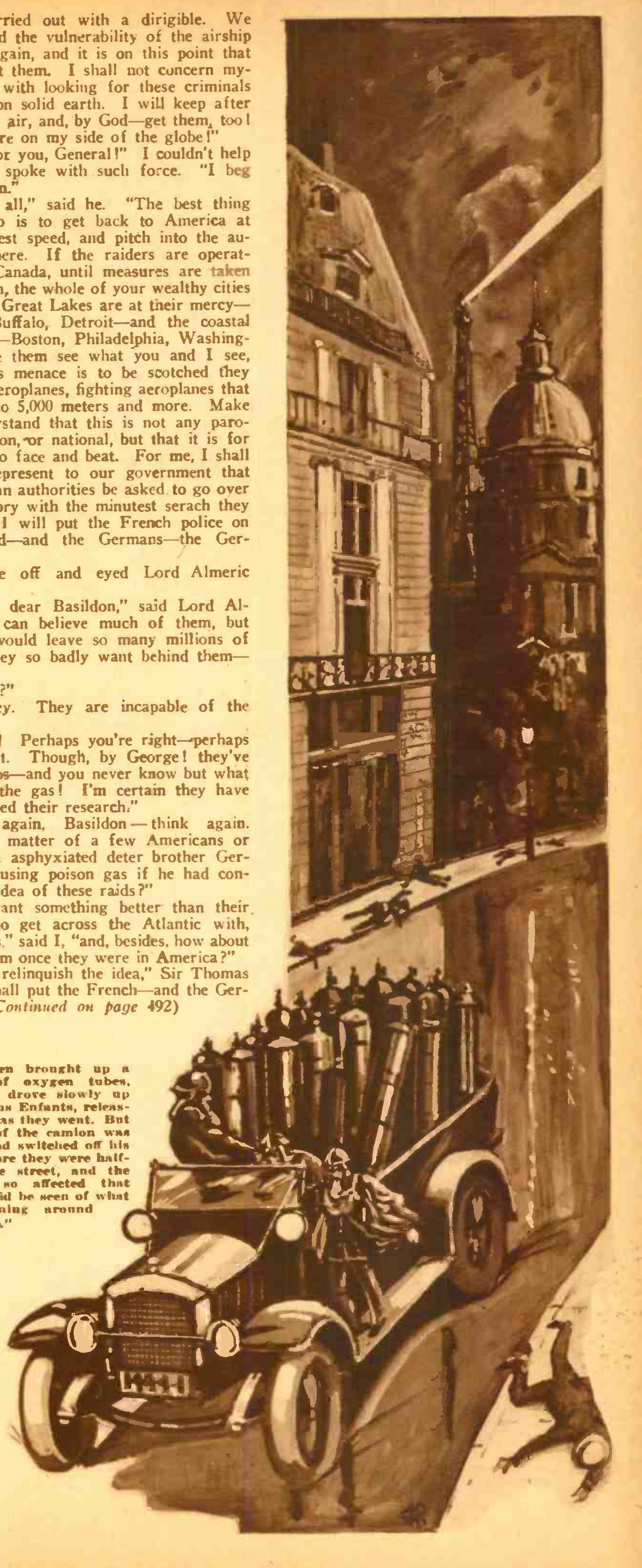
"Humph! Perhaps you're right—perhaps you're right. Though, by George! they've got the ships—and you never know but what they have the gas! I'm certain they have never stopped their research."

"Think again, Basildon — think again. Would the matter of a few Americans or Englishmen asphyxiated deter brother German from using poison gas if he had conceived the idea of these raids?"

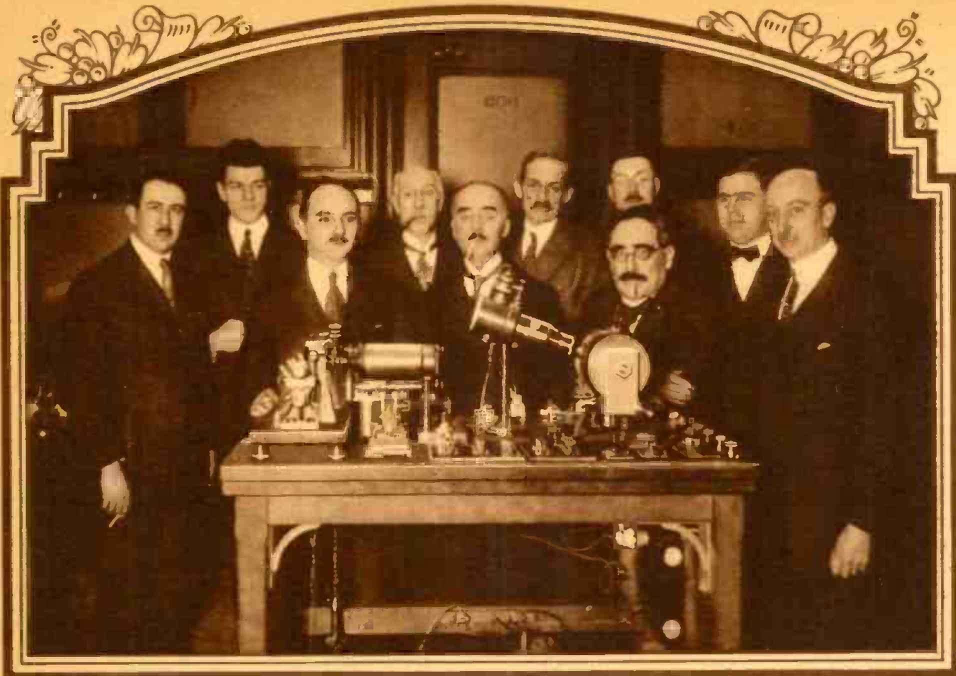
"They want something better than their Zeppelins to get across the Atlantic with, Sir Thomas," said I, "and, besides, how about housing them once they were in America?"

"Well, I relinquish the idea," Sir Thomas said. "I shall put the French—and the Ger-

(*Continued on page 492*)



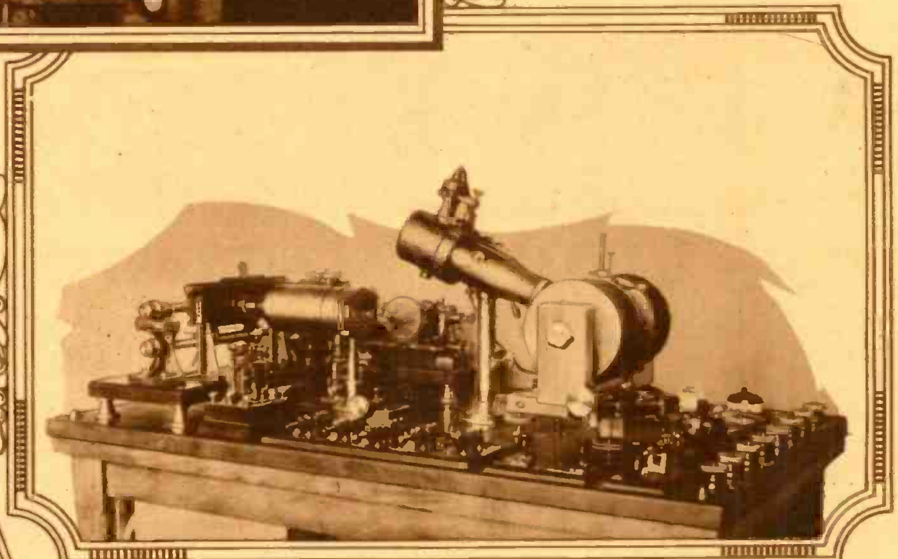
"They even brought up a wagonful of oxygen tubes, which they drove slowly up Rue des Bons Enfants, releasing the gas as they went. But the driver of the camion was overcome and switched off his engines before they were half-way up the street, and the crew was so affected that nothing could be seen of what was happening around the Banque."



Transmission of Autographs and by Wire and

(Abstract from an Article by Edouard Belin)

The photograph at the left shows the Belin telephotograph receiver recently installed in the offices of "The World" of this city. The inventor, Edouard Belin, is shown at the center of the picture immediately back of the apparatus. Mr. R. E. Lacault, formerly of Radio News, is shown second from the left. Mr. Lacault and the gentlemen at his sides, assistants of Belin, worked with the latter in the development of this apparatus.



Another view of the Belin receiver showing the inclined projecting lantern near the specially designed oscillograph. A simplified diagram with the apparatus disposed in the same way as in this photograph is shown on the opposite page.

The two pictures above were transmitted by radio by the Belin method. The lower picture shows Chinese script which could not be transmitted by the ordinary telegraph systems.

THE transmission of pictures may be divided into four general classes: One is the transmission of pictures in line, which is called teleautography; next is the transmission of photographs, which is termed telephotography. Then there is the instantaneous appearance of the far distant living image by direct projection on a screen, termed television; and finally the projection on a screen of an animated picture at a distance from the place where it was recorded a short while before. This is telekinematography.

The French postal service transmits teleautographic messages so that the public has only to write its messages on paper with a special ink and of special size, and the exact duplicate is reproduced at the distant station. Typewriters using very small characters effect a reduction of almost 80 per cent. below the cost of a telegram; shorthand can also be used if the receiver is certain of his ability to translate it. In all these apparatus for transmitting writing or photographs, one of the essential points is the maintenance of synchronism between the cylinders of the two stations which carry the original document and that upon which the receiving paper is fastened. Without this synchronism no correct interpretation of the message is possible.

The system most generally employed to this end is the system of "checking the time," either by direct control of the receiver by the transmitter (as in wire-telegraphy), or by local control of the apparatus by means of metronomes. By isochronism is meant the adjustment of the metronomes to equal time intervals or beats, while synchronism determines the simultaneous starting and completion of each set of oscillations. In cases where the receiving apparatus can be controlled by the transmitter, the speed of the driving motor is so adjusted that the receiving apparatus turns a little faster than the transmitter, but is arrested in its motion once in each turn for a very short interval and does not resume its motion until the transmitter has completed its corresponding turn. This result is attained by sending over the line a controlling current, which does not reach the recording apparatus but passes through a relay which actuates an electromagnet whose armature controls the motion of the receiver.

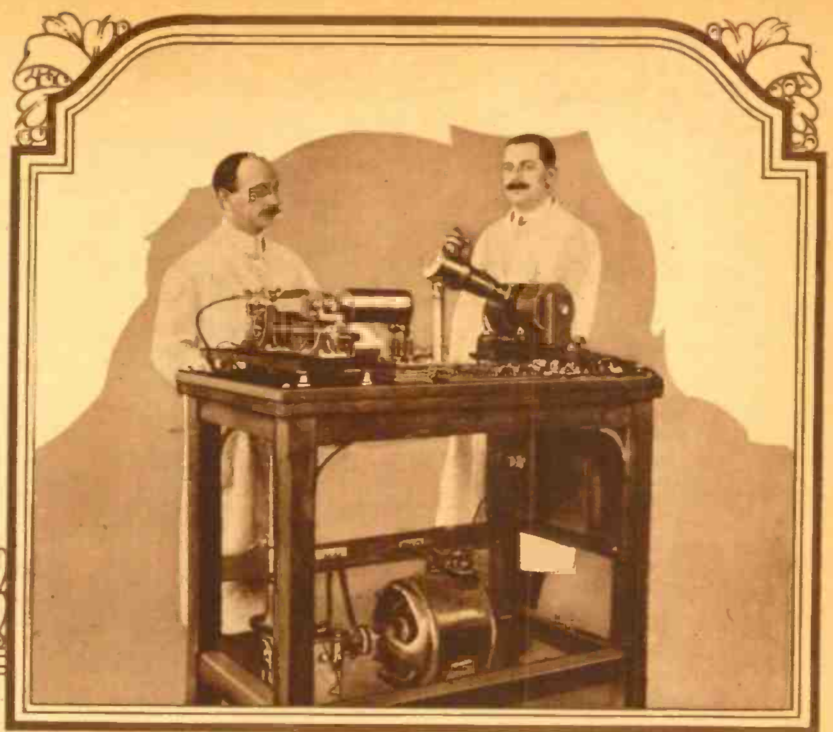
The inventor Korn has developed a system of transmission of photographs based on the effect of light in changing the resistance of selenium.

Picture transmission will be found treated in *Practical Electrics* for March, August and September, 1923, and television, or seeing at a distance, is described in the March and October numbers of 1924.

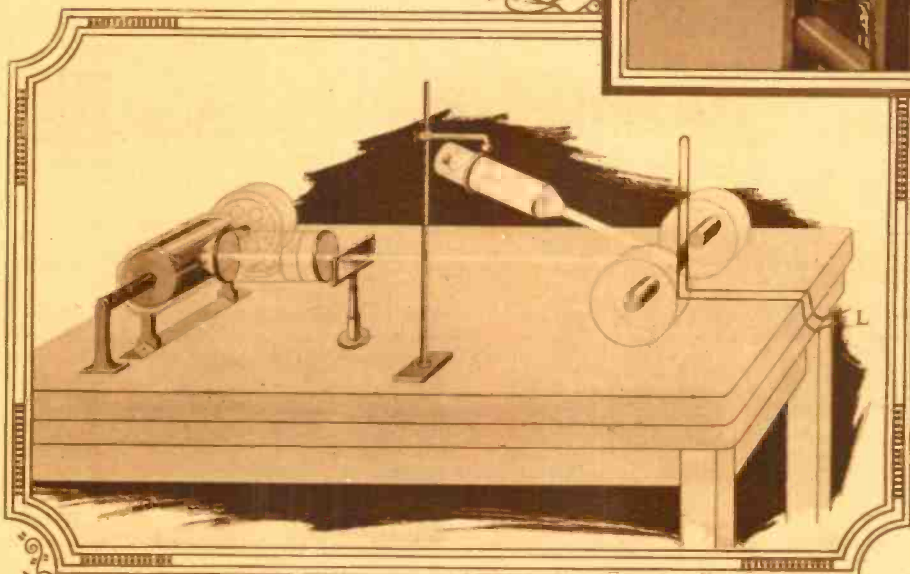
Here we have to deal with the controlling mechanism for the transmission of pictures

(*Continued on page* 476)

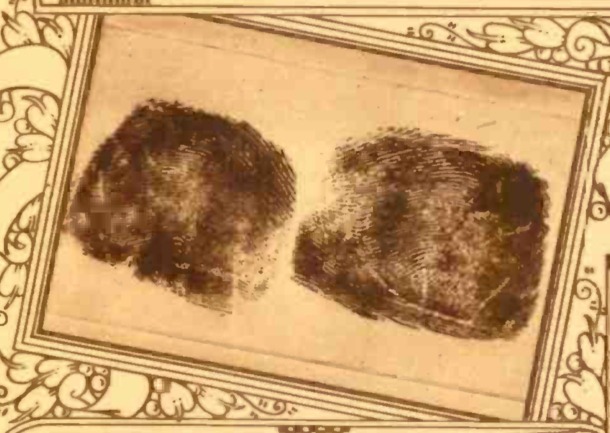
Pictures, Printing, Finger Prints, by Radio



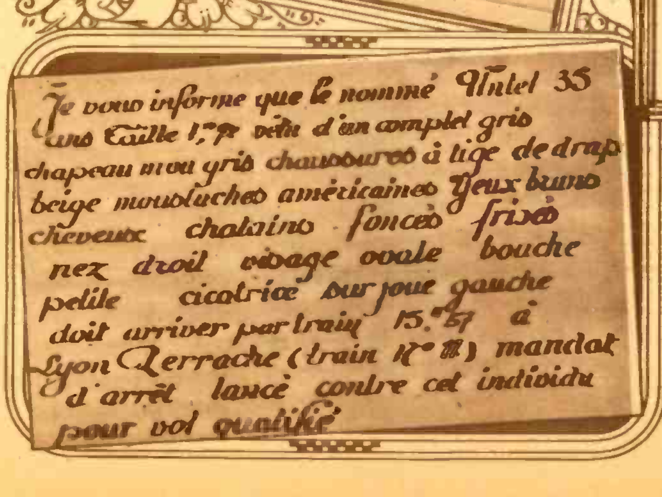
At the right Messieurs Masson and Touly are shown experimenting in Belin's laboratory in France. Belin's laboratory is noted for its equipment and especially for the remarkable experiments which were successfully carried out there by the great inventor.



In the Belin telephotograph receiver the transmission lines are connected to the movable coil of an oscillograph. A very fine ray of light is projected on a small mirror carried by this coil and the reflected beam vibrates in accordance with the vibrations of the coil. The beam falls upon a plate glass of varying transparency, ranging from perfect transparency to perfect opacity. Varying quantities of light are thus transmitted to a lens which focuses the beam and projects it on a photographic film carried by a drum, which rotates and moves axially past the lens. In this way a relation is established between the intensity of light projected on the film and the vibration of the oscillograph coil.



One of Belin's most remarkable achievements is the portable transmitting apparatus shown above. Provided with this, a reporter located at some remote point can transmit photographs and documents over an ordinary long distance wire.


Je vous informe que le nommé Untel 35 ans taille 1,70 vêtu d'un complet gris chapeau mou gris chaussures à tige de drap beige moustaches américaines yeux bruns cheveux chatains foncés frisés nez droit visage ovale bouche petite cicatrice sur joue gauche doit arriver par train 15.57 à Lyon Perrache (train N° [illegible]) mandat d'arrêt lancé contre cet individu pour vol qualifié

At the left is a message received by the French Police Department by means of the Belin system. The message described in detail a pursued criminal and supplied at the same time the finger prints of the fugitive.

The Charge of the Electron

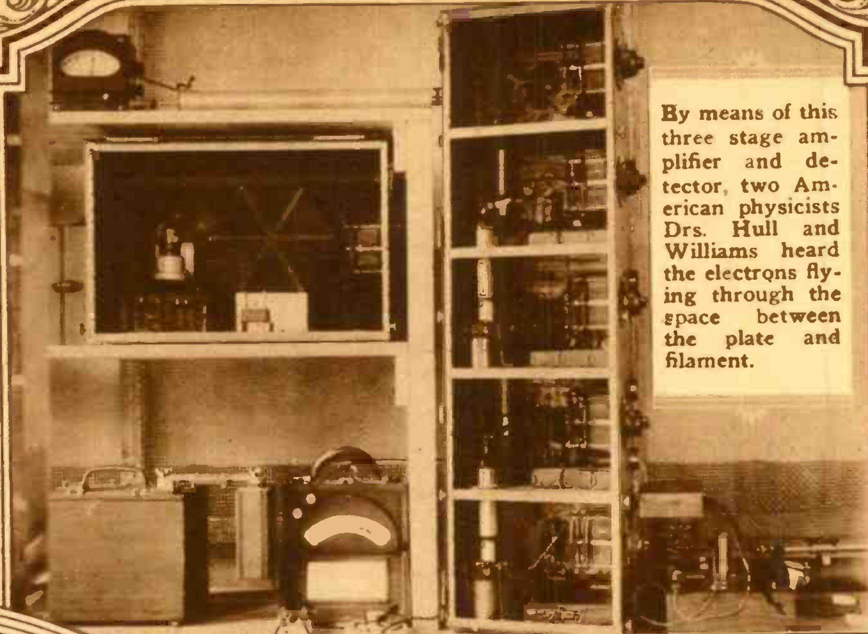
WITH the sudden and extensive growth of radio industry and the popularization of various radio apparatus, especially the vacuum tube, certain elements of abstruse science have come to public notice. The electron which some 40 years ago was a word of limited application and circulated only in journals of scientific societies, has now invaded the vocabulary of the layman. So today the electron enjoys an unprecedented popularity. It is well known, for instance, that the electric current is due to a flow of electrons, each electron carrying a small quantity of energy and so by moving from one place to another in a circuit it transfers that energy from the source to the place of consumption.

This quantity of energy is the same on all electrons, and has been the subject of numerous investigations ever since the electron theory was first advanced. Measurements have been made by a number of prominent physicists using a variety of methods.

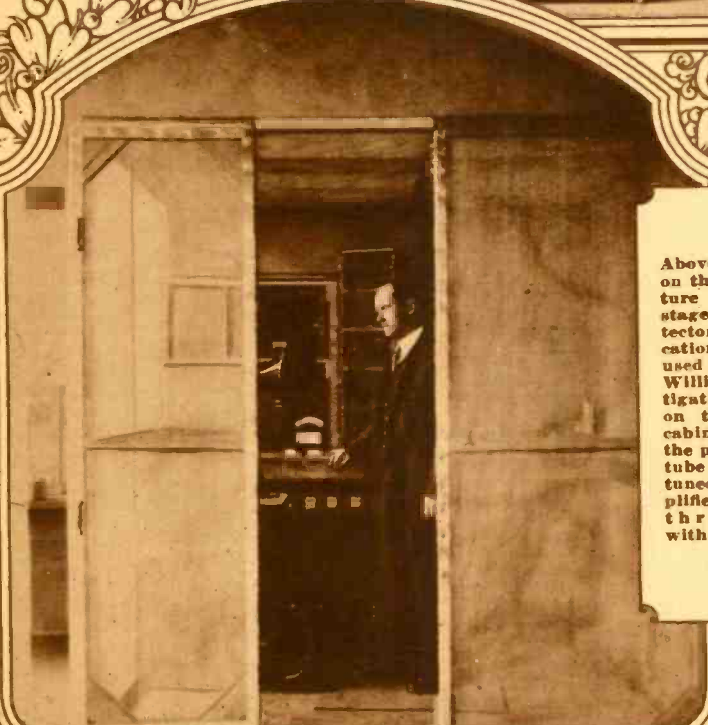
It is interesting to observe, and to the physicists especially gratifying, that the methods of modern science have developed to a stage where the charge, the mass and the velocity of invisible particles such as the electron can be measured accurately.

The occasion of the present article is the measurement of the charge of the electron by a method radically new, and yielding results of unprecedented accuracy. The method will be of special interest to those interested in radio apparatus in so far as the investigators employed vacuum tubes for the study of the electrons to be measured.

(*Continued on page* 477)



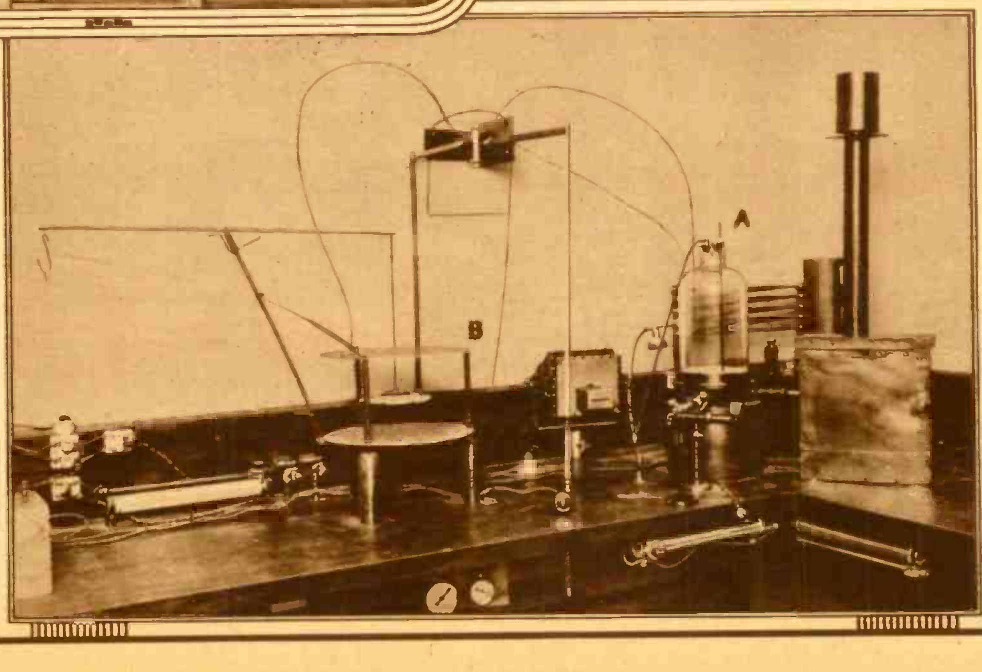
By means of this three stage amplifier and detector, two American physicists Drs. Hull and Williams heard the electrons flying through the space between the plate and filament.



Above: The tall cabinet on the right of the picture contains a three-stage amplifier and detector, with an amplification factor of 70,000, used by Drs. Hull and Williams in their investigation of the charge on the electron. The cabinet on the left of the picture contains the tube under test and a tuned circuit. The amplifier consisted of three pliotrons each with an amplification factor of 42.

Above: Each stage of the amplifier was carefully sheathed in copper. Even the tubes were covered with copper cylinders and the entire equipment with which the tests were performed was enclosed in the wire cage shown.

The photograph below shows Professor Millikan's apparatus (A) for determining the charge on the electron. In this apparatus Millikan isolated an electron on which a drop of oil had been condensed, and measured its motion in an electric and gravitational field. The model at (B) illustrates its operation: a silk membrane is made to move in this model between two charged plates exactly, as the oil drop moves between two electrically charged discs in the apparatus (A).

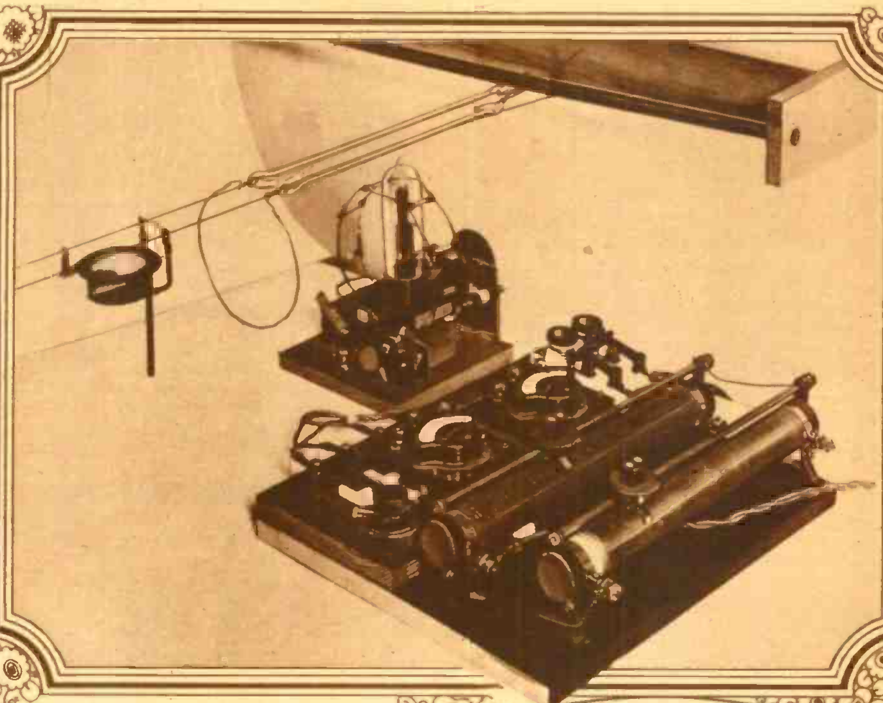


Measuring Radio Wave-Lengths With A Meter Stick

THE signals coming from the usual radio transmitting stations are "broadcast"; that is, they are radiated in all directions. When, however, a conductor such as a wire is available between a transmitter and a receiver, the radio waves follow the conductor and will not be broadcast. That is, the wire "conducts" the waves in one direction. This is the essential difference between wire and wireless telegraphy.

When waves of alternating electromotive force are impressed upon two parallel wires, each wave will travel along the wire to the end where it is reflected. If these waves are continuously produced at the generating end, the reflected waves coming from the receiving end will meet the outgoing waves and at some points interfere with, and at others reinforce, them. The result of such interference and reinforcement is the production of a variation in potential along the wires. This variation is regular, a maximum potential being followed by gradual decrease to zero and then another maximum and so on. The position of these maxima and the interval between them depends upon the capacity, inductance, resistance and leakance of the wires. A mathematical analysis of these four constants of the circuit shows that two successive maxima of potential or current are separated by a distance equal to half a wave-length.

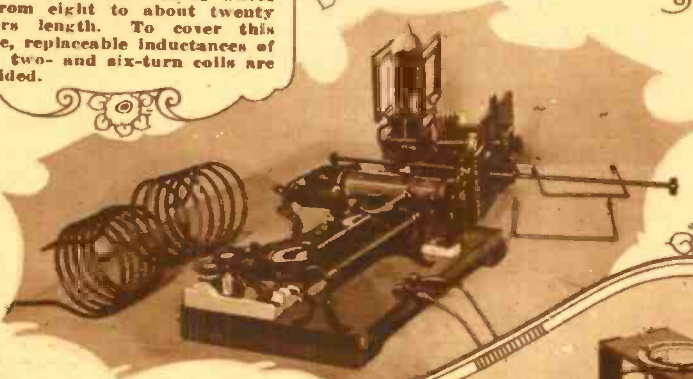
F. W. Dunmore and F. H. Engel, of the Bureau of Standards, have made a very ingenious use of the phenomena described above in the measurement of wave-length

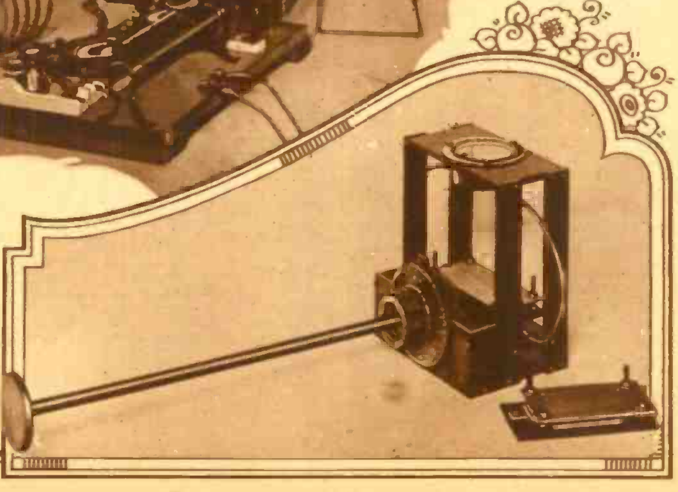


2. The photograph shows a short wave oscillator coupled to a system of two parallel wires along which the thermogalvanometer is moved to determine points of maximum wave intensity. The oscillator radiates an eight-meter wave.

7. Below is an ultra-radio-frequency receiver used in wave-length measurements at the Bureau of Standards. The receiving elements consist of a single turn loop shunted by a low capacity variable condenser and connected to an amplifying system.

5. The oscillator below was designed to radiate short waves of from eight to about twenty meters length. To cover this range, replaceable inductances of one,- two- and six-turn coils are provided.





6. The wavemeter at the right was calibrated with the apparatus shown comprising a single turn loop in series with a thermo-galvanometer, shunted by a fixed and a variable condenser.

of radiations of very high frequency. The method can be readily used by a skilful amateur experimenter. Briefly, the procedure is as follows:

To the parallel wires shown in Fig. 1 a high frequency oscillator is coupled. The circuit is set in oscillation and the low resistance current-indicating instrument (A) is moved along the wire. The dotted lines indicate the magnitude of the deflection of the instrument. The distance between two maxima such as I, I and II, II is half the wave-length (L/2) of the impressed radiation.

In the experiments performed at the U. S. Bureau of Standards two lines of bare No. 14 B. & S. copper wire, 45 feet long, were employed. These wires were strung between glass insulators and kept under tension by strong springs. The interval between the wires was 1.58 inch. The wires terminated in a loop as shown in Fig. 2. A thermo galvanometer having a full-scale deflection of 115 milliamperes was mounted as shown so that it could be moved readily along the wires. When the oscillator, which will be described later, was properly coupled to the lines, the deflections of the galvanometer gave very clear indications of a stationary wave along the wires. It was found that a piece of No. 14 copper wire shunting the galvanometer terminals improved the sensitivity of the instruments by decreasing the resistance of the circuit and thus increasing the sharpness of resonance.

50-Watt Short Wave Oscillator

Fig. 2 shows a carefully designed short-wave oscillator employed by the Bureau of Standards in short-wave measurements. The oscillating circuit consists of two single turns

(*Continued on page* 479)

Historic Experiments

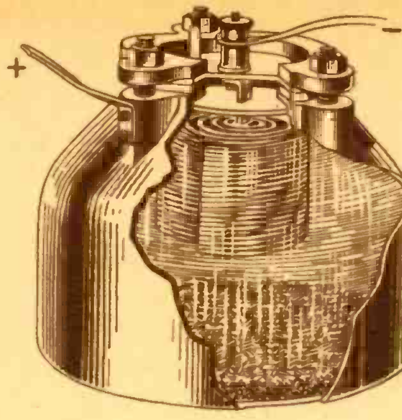
Number 7

Later Batteries of the Nineteenth Century

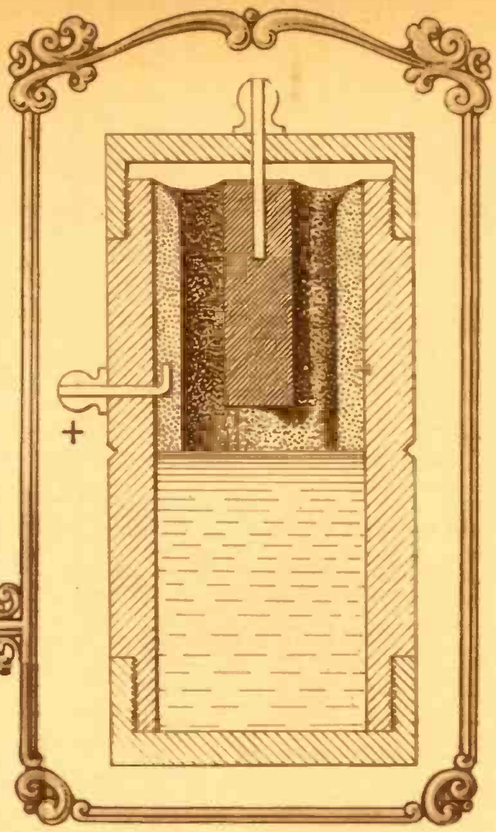
THE first trouble with the early batteries was the evolution of hydrogen from the zinc plate with the consequent wasteful solution of the zinc. The proper power of the battery, if it may be so called, was only obtainable in the first few seconds. This difficulty was overcome in the early part of the century by amalgamating the zinc, which was one of the first great improvements in the battery.

Another trouble was polarization. Hydrogen accumulated on the surface of the copper plate, as it was in those days, making

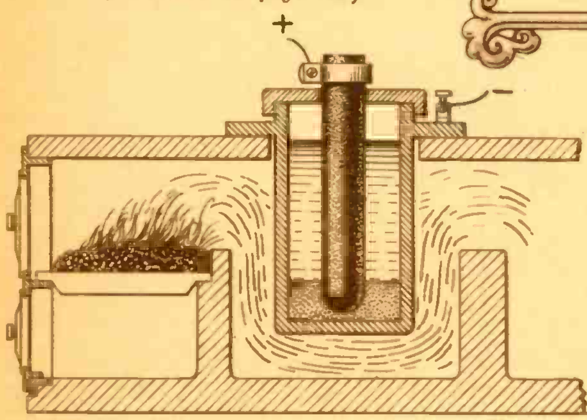
(*Continued on page* 492)



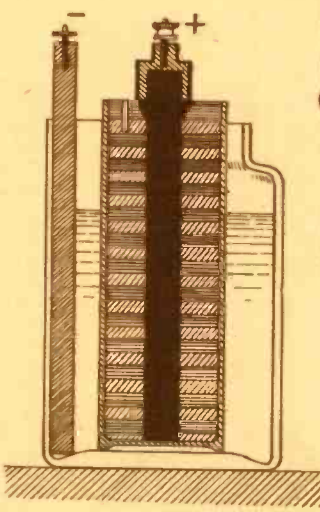
Lalande and Chaperon cell, above, consists of a cast-iron vessel and positive electrode of a zinc spiral immersed in an alkaline solution. The bottom of the vessel is covered with a layer of copper oxide.



Trouvé reversing cell. Zinc rod and carbon cylinder sealed in insulating case with solution of sulphate of mercury. In operation the cell is inverted and the electrodes become immersed in the electrolyte. The cell is shown above in its non-operative position.

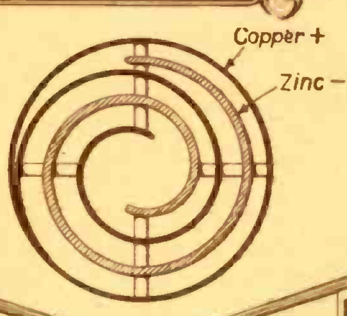


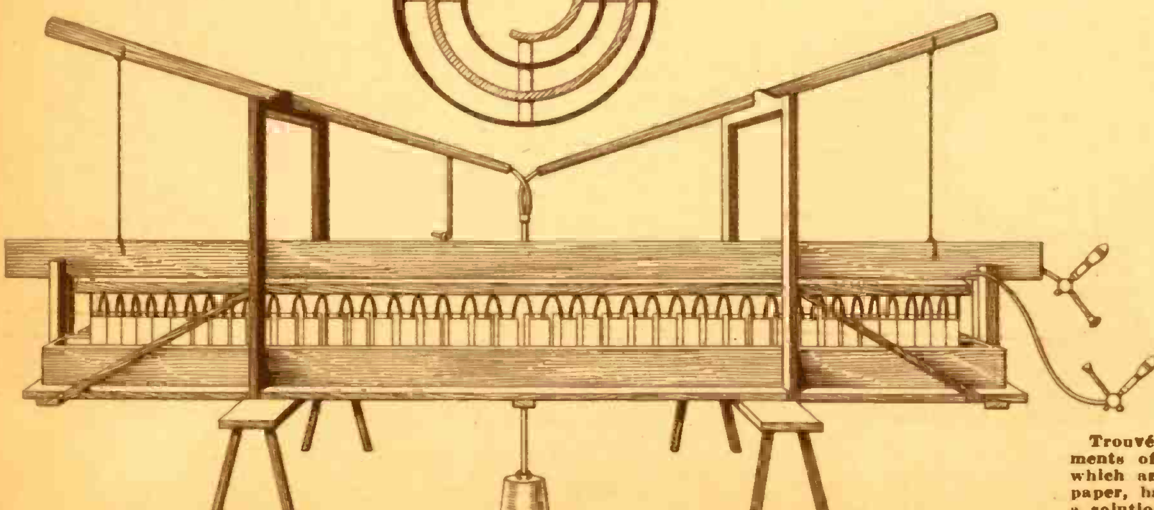
Edison heat cell, above. Carbon rod, an active oxide being used as electrolyte, in a case forming the negative electrode. The heat of the furnace fuses the oxide and causes combination of carbon with resulting oxygen. Electric current flows during oxidation.

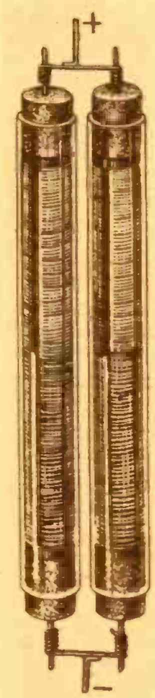


An earlier Gaiffe cell (1875) at right. Zinc, solution of ammonium chloride; porous cup containing a carbon, around which are alternate layers, superposed, of binoxide of manganese and granular carbon.

Hare's Deflagrator shown below consisted of 80 cells using spiral elements of copper and zinc in dilute sulphuric acid. The electrodes were all suspended from a horizontal beam by means of which they could be removed from solution when not in use. The cells resembled the Offershaus helical cell shown in the preceding issue of "The Experimenter."







Trouvé moist cell, above. Elements of copper and zinc between which are several discs of blotting paper, half of which are wet with a solution of zinc sulphate and half with a solution of copper sulphate. When not in use, the discs are allowed to dry.

Getting on the Air

(Continued from page 448)

and hold it in position with one foot so that as it goes up at an increasing angle, it will tend to slip down into the soil pipe. Once the mast reaches an angle of about 80°, it will readily slip down into the pipe. When placed perpendicular, the guy wires should be run out to their anchors and temporarily fastened. Concrete is then poured into the soil pipe and packed solidly around the mast. This should be allowed to thoroughly set before any attempt is made to fasten the aerial in position. After the concrete is set, the guy wires should be tightened up permanently and firmly fastened in position.

The Aerial

There has of late been some discussion about the kind of wire to be incorporated in an antenna, and it has been proven that, particularly on short wave-lengths, and with low power transmission, enameled wire is far superior to ordinary bare wire. No. 12 is an excellent size both from a mechanical and electrical standpoint, although No. 14 is somewhat cheaper and will give excellent results. The latter is the size used in both the writer's antenna and counterpoise. In this case the antenna consists of two wires, the flat top portion being 50 feet long. The distance from the house to the antenna mast is 90 feet and the remaining 40 feet consists of two strands of No. 14 galvanized iron wire broken up at 10-foot intervals by small porcelain "eggs," two "eggs" being used between the ends of the antenna wires proper and the galvanized iron wires.

The lead-in consists of two wires twisted together, which reach from the antenna to the aerial switch mounted on the operating table. A ten-inch electrose insulator is placed at the end of the bridle as shown in the photograph herewith and fastened by means of several strands of wire to the house. Many experimenters prefer glass insulators either of the purchased type or home-made. In the latter case, recourse may be had to glass towel rods which may be readily purchased at any hardware or house furnishing store at a very low figure. Clamps at either end of the rods may be quickly made for fastening the wires thereto.

The Counterpoise

At 3MO the counterpoise consists of a five-wire fan with the apex at the house as shown in the photograph. These wires fan out so as to cover a space 50 feet long at the far end. Each wire, like the antenna, consists of 50 feet of enameled copper wire, the remainder of the length consisting of galvanized iron wire broken up at intervals with small porcelain insulators. The method of fastening the far end of the counterpoise is as follows. A single length of No. 14 galvanized iron wire is run from the top of a convenient shed to a tree at right angles to the direction of the antenna and about 10 feet from the ground. The counterpoise wires are run to the supporting wire and fastened there to guy wires, being run down at an angle to the fence so as to prevent the supporting wire from stretching.

Generalities

In the paragraphs above the writer has attempted to present to the reader the exact details of the transmitting antenna system used in his particular station. By no means is this intended to be a complete set of directions to anyone contemplating the erection of a transmitting antenna. In fact, there will be hundreds of cases where the specific details given cannot be followed. It will be necessary for each individual to study his local conditions so as to determine just exactly how he is going to erect his own antenna and what form it will take. Many amateurs prefer a cage antenna where, instead of straight spreaders, hoops of metal or wood are used and five or six wires are equally spaced around the circumference of them. In such a case the lead-in should also be in cake form. With any type of antenna a fan-shaped counterpoise as described above will give perfect satisfaction, although if desired or if space dictates, a second cage, similar in all physical characteristics to the antenna may be erected. In any case, the counterpoise should be considerably lower than the antenna, although it need not run directly under the latter or parallel with it. Very often counterpoises are run at a considerable angle to the antenna and in some cases they run in opposite directions. Apartment house dwellers often have obtained excellent results with an antenna and counterpoise separated by only 10 feet. However, under normal conditions this is not to be recommended and where space permits, they should be at least 40 feet apart at their extremities. Even in the writer's case it was not practical to do this and at the house end they are only separated by 12 feet, although at the far end this distance is increased to 40 feet.

The question of the insulation of the aerial and counterpoise was quite thoroughly discussed above. Pay full attention to this point, and furthermore do not forget that at the points where the lead-ins from the counterpoise and antenna enter the house, excellent insulation must be used. Porcelain tubes will suffice for low powers, although if you ever contemplate using 10 watts or more of power, it is advisable to secure large insulators for bringing in the lead-ins.

Recent experiments by several second district amateurs have pointed toward the fact that single wire antennas and counterpoises give excellent results, particularly on short waves and with low power. During the coming summer, the writer is contemplating undertaking a series of experiments along this line and the results will undoubtedly be published in a future issue of this magazine.

Considering the information given above, you should now be able to go ahead and erect a suitable antenna and counterpoise, bearing in mind that they must be well insulated from the ground. An antenna of the particular type in use by the writer today and described in detail above is suitable for transmission on either 80 or 175 meters and was so designed. Future articles will deal with the construction of transmitters capable of operating on these wave-lengths, and when these articles are published, if you have followed directions herewith, you will be equipped with an antenna suitable for use with the sets to be described inasmuch as these sets will have been built and tested on that particular antenna.

Since you have been listening in on amateur transmission for the last month or so the writer believes that he can safely say and be understood when he says, "73 OMs CUL."

Experiments with Static

FOLLOWING are a few experiments that can be performed with a hard rubber comb and an audion receiving set.

Rub the comb with silk or pass it through your hair a few times, and it will acquire a static charge; then hold it about a quarter of an inch from the ground or aerial binding post of a radio receiving set, as in Fig. 1. A distinct click will be heard in the headphones or loud speaker if the set is working. This phenomenon corresponds to the static we hear over our radios during electrical storms.

Charge the comb again and discharge it on the grid terminal of the detector tube socket. A louder click will be heard than previously, which is due to the increased current on the grid which causes a similar variation in the plate current. Fig. 2 illustrates this experiment.

By discharging the comb on a phone tip terminal as shown in Fig. 3, the discharge will be heard plainly.

A Wimbhurst static machine, as well as static discharges through the lightning arrester, will produce similar results.

Contributed by Hugo E. Anderson.

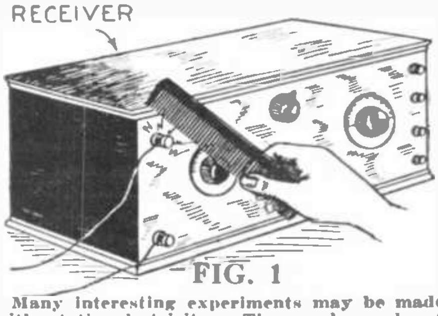


FIG. 1

Many interesting experiments may be made with static electricity. The comb, made of hard rubber, becomes charged and, as shown above, may be discharged by touching it to the grounded side of the set, you will notice a blue flash. During very dry days you yourself may become charged with static electricity by merely shuffling your feet along a heavy rug and, touching a radiator or water-pipe, will notice the static discharge. A Wimshurst static machine will enable you to carry out experiments along these lines to a greater degree. Heavy charges may be obtained and "hair-raising" experiments, in the true sense of the word, may be made. By insulating the body, the experimenter changing that body with a static machine, and placing his hand over head, makes hair actually stand on end.

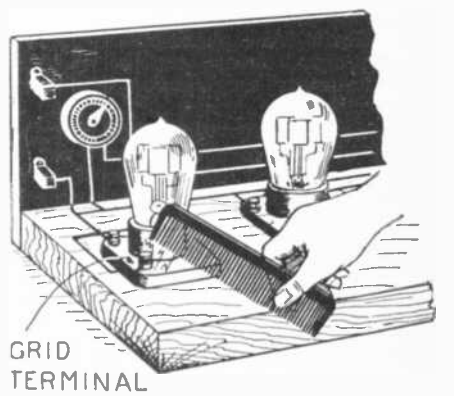
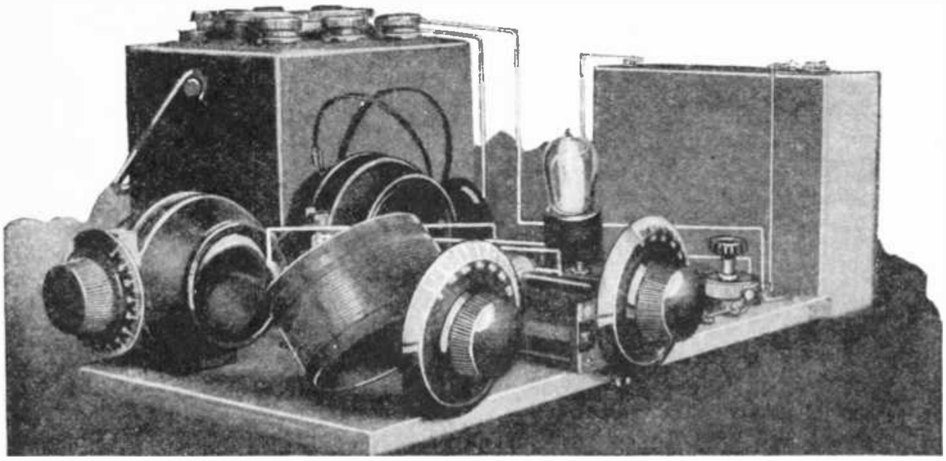


FIG. 2

You may listen to the static discharge by discharging the comb on the grid of the tube. Many other interesting static experiments may be made in conjunction with the radio outfit. A glass rod is likely to give a more powerful discharge, especially if rubbed with cat's fur or a silk cloth.

Single Tube Regenerative Circuits for the Hook-up Board

By Abner J. Gelula



The layout for the experimental test-board. Note the arrangement of the apparatus. All dials are easily accessible for variation of wave-length and regeneration. This layout, besides being used for single-tube regenerative circuits, may be, with the addition of another tube, a test-board for radio frequency amplification tests. If the addition of another tube is disagreeable, the apparatus may be used for building one stage of R.F. and connecting the output into any standard radio receiving set.

In the February issue of The Experimenter we thoroughly discussed radio frequency amplifier circuits, several of which were given on page 242. A few of these circuits utilized regeneration, but the majority were of the straight radio frequency type.

We shall now consider the straight regenerative circuit utilizing one tube only. Without doubt, regeneration properly applied results in an ultra-selective as well as a very sensitive circuit.

It often requires much consideration on the part of the experimenter or novice radio man to determine whether radio frequency, regeneration, or audio frequency should be used for a given number of tubes. Before attempting to build a complete set, always give thought to the requirements involved and to external receiving conditions.

Of course, audio frequency amplification should be placed, if possible, at the output of every receiving set. Audio frequency amplification increases the practical receiving range of the set as well as the volume.

If volume is preferable to distance reception, radio frequency amplification would not do, as this type of amplification will boost only the energy intercepted by the aerial. Radio frequency amplification amplifies the signal before rectification, while audio frequency amplification amplifies it after rectification.

Considering the question whether a given number of tubes are to be used for the audio side, we must ask ourselves the above questions as well as give thought to other factors.

Regeneration may be added to the circuits given on the opposite page by merely placing one tube ahead of it, the primary and secondary coils acting as the inter-stage coupling.

Regeneration is equal to a little over one stage of tuned radio frequency. Therefore, by the addition of regeneration plus R.F. and with the conventional two stages of audio, this type of set might be considered ideal.

The circuits given on the opposite page are of the one tube regenerative type. The hook-up board as shown in the illustration contains two variometers, one variocoupler, a variable condenser (.001), a socket and a rheostat. They are connected together according to the desired diagram. Clips or cord tips were used for the making of rapid connections.

The experimenter will find that a board of this type, left assembled, will be invaluable in general experimentation. Variometers may be used in many points of the circuit other than grid and plate leads. The variometer may be used very successfully for inter-stage radio frequency transformers, primary or secondary tuning devices or for general wave-length control.

In this issue we shall consider only the one tube regenerative outfit, presenting on the opposite page ten tested, one-tube regenerative circuits for the test board.

Fig. 1 is the usual variocoupler, two-variometer circuit. A soft tube is preferable for detection, with a low voltage on the plate. The aperiodic primary is wound directly over the secondary. It is very important that the variometer in the circuit be capable of tuning throughout the wave-length range of 200 to 600 meters.

LIST OF PARTS

- 2 *Atwater-Kent* Variometers
- 1 *Hammarlund* 43-plate Condenser
- 1 *Shamrock* 3 Circuit Coupler
- 1 Soft Wood Board 20x10x½"
- 1 *Na-Ald* Tube Socket
- 1 *Rasco* 30 ohm Filament Rheostat
- 8 Double Spring Binding Posts
- 5 Single Spring Binding Posts
- 18 *Rasco* Test Clips
- 12 *Rasco* Test Points
- 1 Grid Condenser (.00025 mfd.)
- 1 Grid Leak (2 meg.)

Fig. 2 shows how a three control set may be built by using two variometers and a variable condenser. As stated in the preceding paragraph, the variometers must tune throughout the entire broadcast wave band. The variable condenser is of a .001 mfd. capacity (43 plates approximately). The grid leak may be connected across the grid condenser rather than from grid to filament. It will be found that the regeneration will be slightly difficult to control if a dry cell tube is used. By the use of a soft tube the regeneration may be controlled with the aid of the rheostat.

Fig. 3 shows the tickler feed-back method of regeneration control. The primary is aperiodic, wound over or directly beneath the secondary. The tickler is variable. The primary, secondary and tickler comprise a three-circuit coupler, and with the secondary tuning condenser, which is of a .0005 mfd. capacity, the set operates very efficiently despite the fact that there are but two controls.

Fig. 4 is a split variometer circuit. A two-circuit tuner may be used in place of the single circuit affair shown in this diagram. This circuit operates very efficiently on broadcast wave-lengths and is comparatively easy to tune. It will be found to be a simple matter to "split" the variometer. The variometer is composed of the rotary and stationary coil connected in series. In order to split the variometer it is necessary to sever this series connection. The connection is usually made either through the end plates or directly on the shaft of the rotor. It is very important that the rotor of the variometer be connected in the plate circuit, and the stator in the grid.

Fig. 5 makes a very interesting experimental layout. We have our two-circuit tuning arrangement in the aerial coil and secondary. The ground coil and tickler are in inductive relationship. It was found that the ground and tickler coil should be out of the inductive field of the primary and secondary coils. For the radio man who enjoys experimenting with freak circuits, Fig. 5 certainly fills the bill.

Referring to Fig. 6, we may be led to believe, at first glance, that it is a duplicate of Fig. 3. This is not the case, however, for this circuit is designed for use in connection with the honeycomb type of coil. The variable condenser in the plate coil is optional. However, should the coils be mounted within the cabinet in fixed inductive relation, this condenser becomes vital. If the three condensers are used, it will not be necessary to touch the coils after they are once adjusted, as the tuning is entirely controlled by the three condensers.

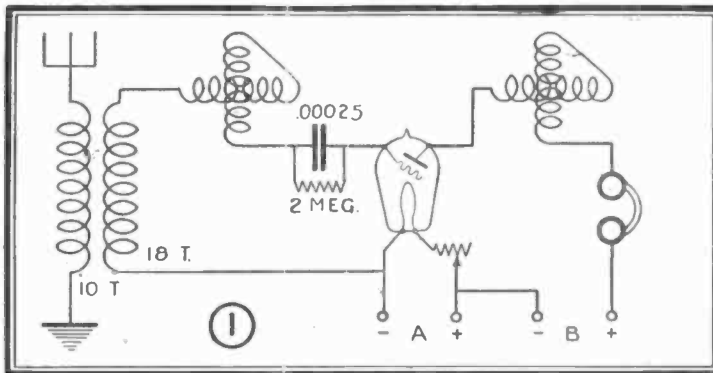
Fig. 7 is a well known ultra-audion circuit using a condenser-tuned plate. The volume is very good, but for the amateur DX receiver, it is doubtful whether this circuit would be suitable. The fixed condenser must not be connected across the grid condenser, for the tube is easily paralyzed.

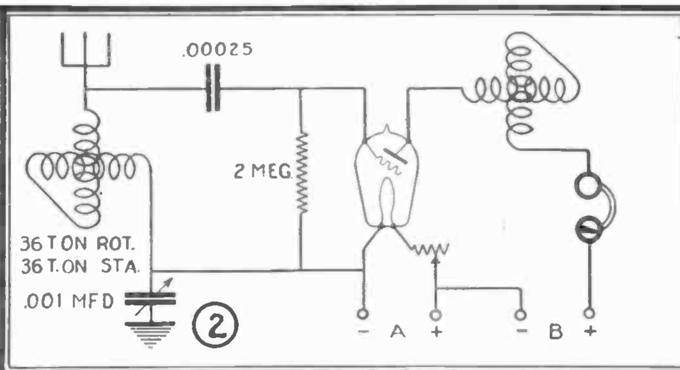
Fig. 8 gives the schematic diagram for a capacitively-coupled circuit. The two coils are in inductive relationship, the plate coil being variable. This circuit will be found very selective and capable of producing good tone and volume. However, for DX many of the other circuits shown on the page surpass or equal it.

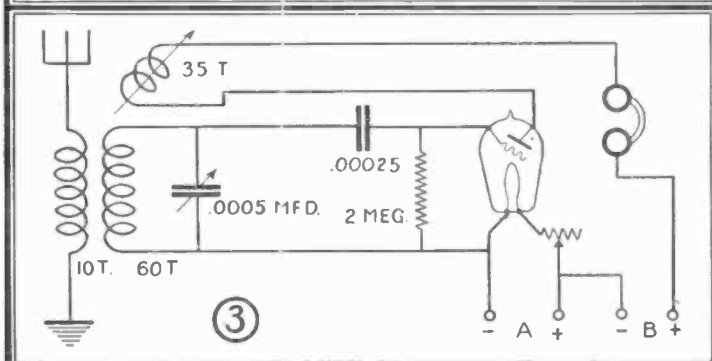
If you live within one mile of a broadcasting station, the circuit shown in Fig. 9 will be found to produce good volume, and is especially useful in vicinities where broadcasting stations are numerous, because it is ultra-selective. The loop to be used with this set should be as large as possible. The 15 turns indicated in the diagram were computed on the basis of a loop two feet square. Of course, if the loop is larger, the number of turns becomes smaller.

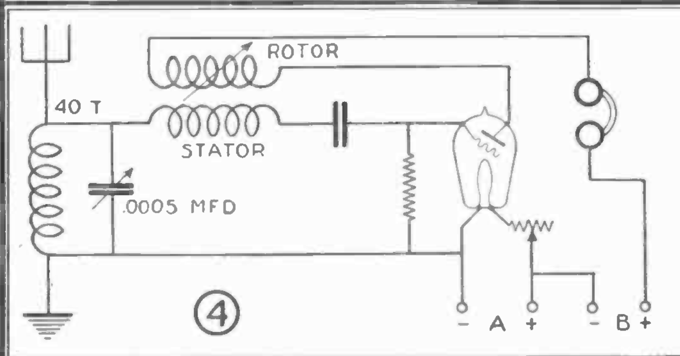
In Fig. 10 we have another circuit utilizing the tickler feed-back system. The two inductive coils in the feed-back system of this circuit may be a split variometer, if the experimenter so desires. Note that the variable condenser tuning the secondary, connects to the filament side of the secondary.

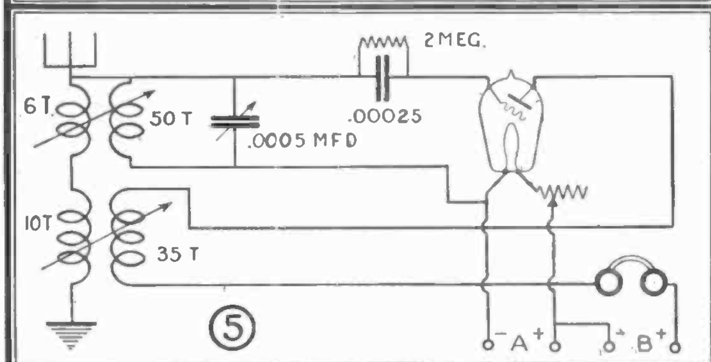
One Tube Regenerative Circuits

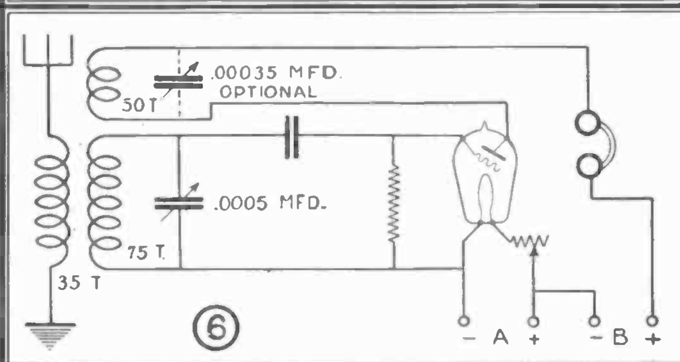


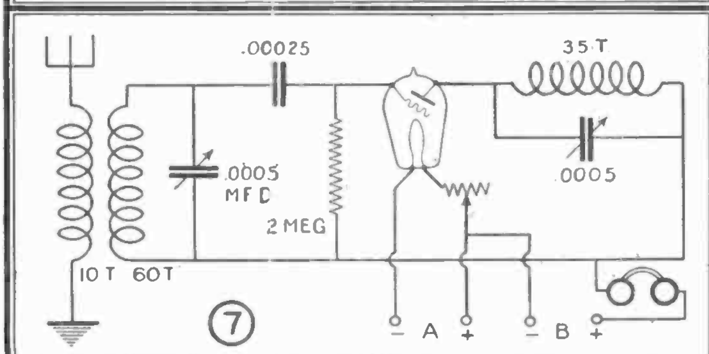


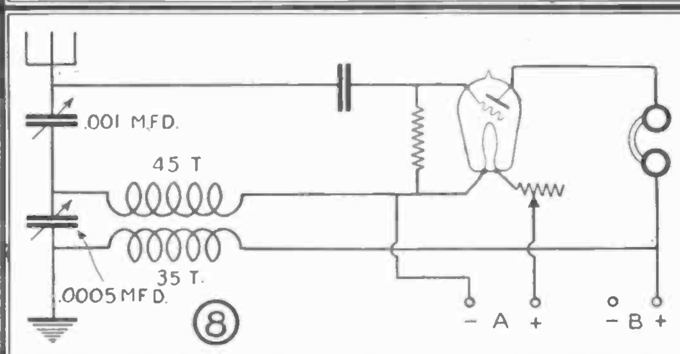


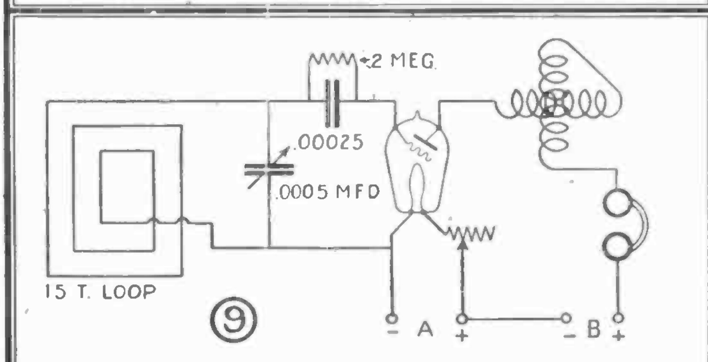












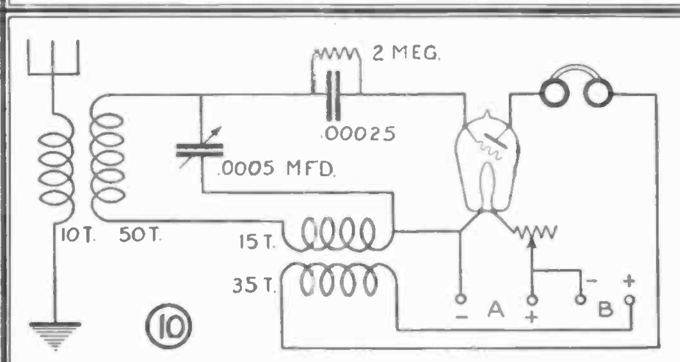


Fig. 1 is a straight variocoupler, two variometer regenerative circuit; Fig. 2 indicates how two variometers and a variable condenser are connected for a one-tube regenerator; Fig. 3 is a tickler feed-back system, while Fig. 4 shows a similar method using the split-variometer; Fig. 5 is to a certain degree a freak circuit, but presents good meat for the experimenter; Fig. 6 gives a honeycomb regenerative circuit, the variable condenser in the tickler coil being optional; Fig. 7 is similar to Fig. 1 except that the condenser replaces the variometer; Fig. 8 is a capacity-coupled regenerative circuit; Fig. 9, for short distance reception and for the radio man desiring the extreme in selectivity, is ideal; Fig. 10 is another method of tickler feed-back.

A Four Stage Amplifier

By S. Stern, E. E.

SOME time ago the author was experimenting with a sensitive radio receiving set, containing, at the output of the detector tube, the usual two-stage audio frequency amplifier. With long distance reception, the signals would come through weak, but clear when using phones, and naturally, when a horn was substituted for the phones no sound was heard.

It was, therefore, evident that a greater audio amplification was required. However, when this was directly applied by adding further stages consisting of transformers and tubes, the result was distortion, ringing and whistling, all combined or appearing singly, according to the number of stages added. Evidently something in the amplifying unit required altering. However, before any of these remedies could be applied, an investigation had to be made as to where the trouble originated.

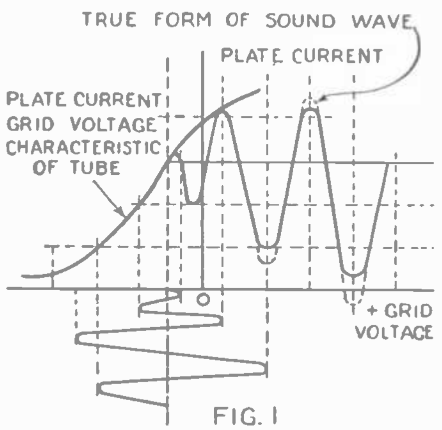


FIG. 1

The above curve shows the form of the sound waves, altered. The broken line shows the true form of this wave as compared with the full line wave which shows the form when the tube is overloaded.

Since the trouble experienced consisted generally of distortion, tube ringing and whistling noises, a direct solution would be to eliminate each of these nuisances separately by tracing their cause. Thus:

Considering that the tubes and transformers are good, distortion is directly due to overloading at the input side of the tube (grid filament side). From our fundamental concepts of tube operation, we know that when the voltage applied to the grid extends beyond the straight line portion of the plate-grid characteristic curves of the tube, distortion results. The form of the sound wave is altered as shown by Fig. 1, where the broken line shows the true form of this wave as compared with the full line wave which shows the form when the tube is overloaded.

But according to the observed weakness of signal in the second stage, the signal voltage could not have been so great in the detector tube as to produce distortion after the usual amplification. Furthermore, the faithful production of the intense ringing noise proved that the straight line plate-grid characteristic of Fig. 1 was not exceeded. Of course, the initiated radio experimenter knows that the cause of microphonic sounds lie in the poor construction of the elements in one or more tubes of the radio set. If any nearby mechanical vibration exists, it will be slowly taken up by these tubes. Such ringing can be stopped by placing, underneath the base of the set, a felt cloth of sufficient softness to absorb these vibrations. The above thus accounts for and remedies the first two of our troubles.

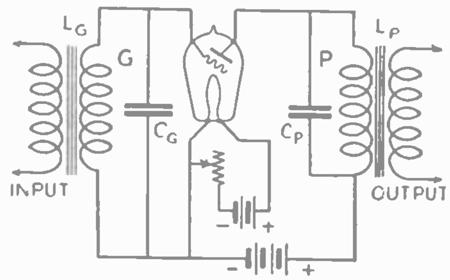


FIG. 2

One stage of audio frequency amplification. Lg and Lp, the input and output transformers, respectively, should have by-pass condensers across the input and output of the tube. This will reduce distortion and increase amplification to a certain extent.

Third, we have the whistling noise which is doubtless the most persistent one encountered in audio amplifiers of two or more stages. The explanation for this whistling may be gained from a study of Figs. 2 and 3. In Fig. 2 we have a schematic diagram of one of the audio amplifying units. In this diagram Lg and Lp represent respectively the inductance shown in the form of turns for the secondary of the input transformer, and Lp the primary for the output transformer. Since each of these coils have many turns, an inherent capacity exists between the turns of each coil which may be represented respectively by Cg and Cp as shown. This by inspection of Fig. 2 gives us two oscillating circuits g and p. The effect of one upon the other will depend upon whether the two circuits g and p have the same frequency when the coupling, as introduced by the tube, is of the right value. How this coupling is brought about may be seen from Fig. 3.

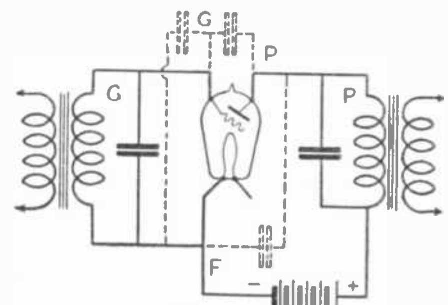


FIG. 3

To some degree the tube couples the input and output transformers, capacitively. The dotted lines indicate where the tube capacity lies.

In Fig. 3 the mechanical construction of the tube causes electrical capacities to appear as shown by the broken lines. Thus we get GF the grid filament capacity, GP the grid plate capacity and PF the plate filament capacity. Inspection of Fig. 4 shows that the new capacities PF and GF add only to the already existing capacities of circuits g and p. GP, however, acts merely as coupling condenser to the circuits g and p. Thus, it is seen that the electrical energy flowing between the filament and plate and modulated by the grid may turn back upon itself through the side path as opened by the coupling condenser GP, and that is what actually happens. The whistle, however, being produced by oscillations started in circuit p by the signal, and since circuit g is tuned somewhat broadly to it, these audio oscillations are passed to the input circuit, namely, circuit g. Obviously, the amplifier unit be-

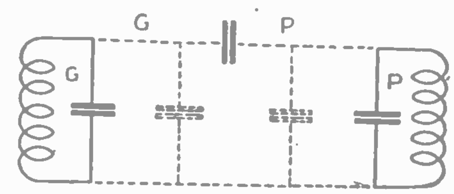


FIG 4

The high frequency by-pass condensers, across the output and input sides of the audio transformers, only add to the already existing capacities created by the elements of the tube.

comes, by this means, a low frequency oscillator. Since such whistling is undesirable, attention must be given to the cause, the grid-plate capacity.

This capacity of course must be done away with or decreased to so low a value as to have no effect. Unfortunately, both of these methods are impracticable, since both would involve changes in tube construction. Going to the other extreme, where a condenser is added to the grid-plate terminals to increase their combined capacity, would seem at first to have a tendency to make matters worse. But such is not the case, as may be shown by mathematical

(Continued on opposite page)

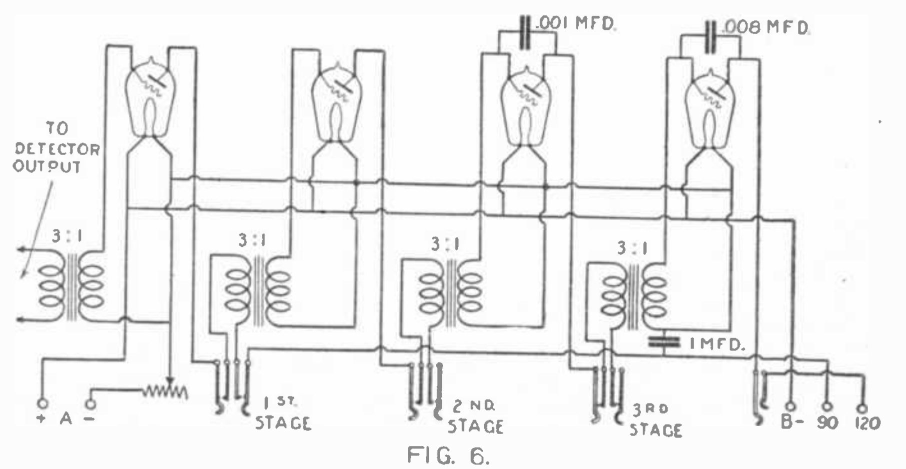


FIG. 6.

A four-stage audio frequency amplifier. Note the capacities across the tube elements of the third and fourth stage.

Reverse Connecting Plug

By Donald E. Learned

THE experimenter often has several pieces of electrical apparatus about the laboratory which he has occasion to connect to the house circuit at times, but does not desire a permanent connection thereto. The portable cord is the best solution. The use of the cord, however, generally requires the making of connections which require almost as much time and trouble as do permanent connections, and, if the number of items to be so connected is large, it requires a large outlay in cordage and plugs, if the cords are left permanently connected.

To avoid this investment of time or money, the reverse connecting plug is very suitable. Such plugs are mounted on the apparatus when constructed, and furnish thereafter a most convenient means of making connections.

Two types of home-made reverse plugs are shown utilizing two different types of plugs, and two different types of cord receptacles, or rather, terminators. The first type is by far the neater arrangement, and much cheaper. Two or three portable cords furnished with plugs on one end and receptacles on the other end, represent the portable equipment. An ordinary connecting plug (cap) is fastened to the apparatus by means of a large-head screw, and suitable notches cut in its rim to permit the entrance of the wire leads to the apparatus. The plug may also be fastened by means of sealing wax, as shown in the lower figure.

The lower figure is given for the benefit of those who have portable cords with lamp sockets attached. It is also convenient when a switch is required at the apparatus.

Cord receptacles can be purchased for either type of plug (cap) shown, and the lead-wires may be entered through either notches or drill holes according to taste. Lamp receptacles may be purchased to fit the cord receptacle for the lower plug, so that the portable cord can be converted into an extension lamp by simply plugging in.

When a number of phones are connected in series, they should always be connected so that the beginning of the phone winding of one phone connects to the end of the winding to the other. You will find that one of these phone cord tips has a red or green colored string run through it. This is to be connected to the plate side of the phone circuit. Too often the experimenter, to his ultimate sorrow, fails to take into consideration the importance of connecting the phones so that the current flow through them is in the right direction.

A "B" Eliminator

By Benville Snyder

EVERY experimenter wants to use the 110-volt A.C. for the plate supply, but the commercial eliminators are too expensive for the average pocketbook. The method about to be described employs the old style chemical rectifier and is much cheaper.

Mason jars are used for this, and it will be necessary to have four. The electrodes are strips of aluminum and lead one inch wide and three inches long. These are fitted to a wooden cap as in the illustration. A saturated solution of borax is mixed and put into the jars.

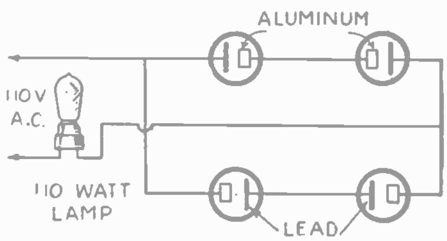


FIG. 1

This is how the chemical rectifier is placed in the circuit. The 110-watt lamp is not standard, but for the sake of simplicity it was thought best to use one lamp to symbolically portray the required wattage. A 100-watt and 10-watt are connected in parallel to obtain the desired draw.

Be sure that the aluminum and lead are as chemically pure as you can obtain. The rectification will then be as near perfect as is possible with this type of rectifier. The top of the jar which supports the electrode should be made of an insulating composition such as bakelite. If this is not easily obtained, a piece of dry, hard wood will fulfill the requirements very nicely.

The plates are now inserted and hooked up as in Fig. 1, with a 100-watt lamp in series. The current is then turned on. At first the lamp will light very brightly, but in about six minutes it will go out.

This forms the plates. This device will rectify the current, but there will still be a hum. To get rid of this, a filter is needed. The filter is composed of a choke coil and two 2-mfd. condensers. It is hooked up as in Fig. 3 and gives D.C. at about 100 volts. For the detector we add another condenser of the same capacity and a variable grid leak to cut down the voltage.

By adjusting the grid leak we can obtain voltages from 12 to 38. A little oil should be poured in each jar to keep the solution from evaporating. This rectifier consumes very little current; in fact, less than a 15-watt lamp consumes. The choke coil may be the secondary of an audio frequency transformer.

Contributed by Benville Snyder.

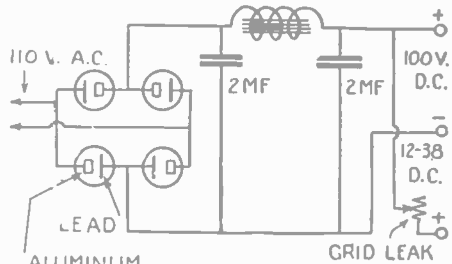


FIG. 2

How the rectifier is placed in the circuit. The filter circuit is composed of a choke coil and two 2-mfd. fixed condensers.

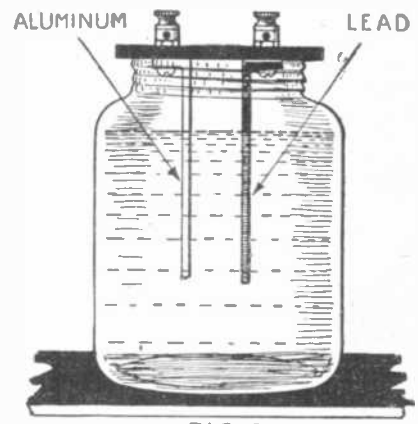


FIG. 3

The above is the completed rectifier cell. Great care should be exercised in the selection of the aluminum and lead in that they be chemically pure. The jar is one of the ordinary mason type and is filled with a saturated solution of borax.

A Four Stage Amplifier

(Continued from preceding page)

analysis, too lengthy to be given here and proven by a form of the Meissner oscillator shown in Fig. 5, where the variable condensers C determine the period of oscillation. In the diagram shown, L1 and L2 are aperiodic, and therefore this circuit will oscillate at all frequencies. Should L1 and L2 be made periodic so that they are adjusted, say, to a high frequency by simply connecting a variable condenser across L1 and also across L2 and should C be of appreciable value, it would be very difficult to make the system oscillate at the higher frequencies for which the circuit is adjusted by the two added capacities. Applying this knowledge to the problem in question, we arrive at the following conclusions:

If a capacity of proper value is connected across the grid-plate terminals of the tube in our audio frequency unit so that the tendency for oscillations is below the audio wave band limit (250 cycles per second), any tendency toward whistling should be stopped. Thus, having solved the problem, the author recommends the circuit shown in Fig. 6 for four stages of audio amplification.

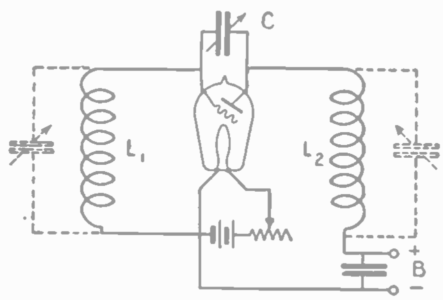


FIG. 5

The Meissner oscillator, where the variable condenser C determines the period of oscillation. L- and L2 are aperiodic and therefore will oscillate at all frequencies.

For best results, only that type of horn should be used that can stand so powerful an output, such as the Western Electric power horn. If three stages are found sufficient, a .002 mfd. condenser across the grid-plate terminals of the last tube will be found sufficient. The transformers used must have closed iron core circuits and the whole transformer must be encased in metal. These experimenters who already have a two-step audio amplifier may add one or two stages more, as desired, considering only the third and fourth stages of Fig. 5. This was accomplished successfully for several commercially manufactured outfits now on the market.

A Home-Made Variable Condenser

By Dr. H. Schuetze

A ROTARY condenser can be bought cheaper than one can make it even if the materials cost nothing. We describe here a sliding condenser which works better than many rotary condensers which are sold, one which can be made in the simplest way, which looks good, and can easily be built into any receiving set.

The maximum capacity of the condenser described here runs up to about .001 mfd. The dimensions are determined by the material at hand and must not be considered as invariable.

We need: three old 5¼ x 7½-inch photographic plates, a piece of sheet metal, zinc, brass or other material, 4 x 5 inches; two connection clips; some tinfoil; some thin wooden board and other odds and ends which will be found in every experimenter's lucky chest.

Cut the base 8 inches long and 6½ inches wide and fasten to it some strongly adhering adhesive tape to the first of the three glass plates. The writer has had great success with chloral hydrate solution of gelatin which one can prepare easily for himself. Fig. 1 shows the arrangement. Then we cut a piece of tinfoil of the size 4¾ x 3½ inches and glue that to the glass plate. For connecting it with the clips provide each piece of foil with a tongue, ⅜-inch wide and 2 inches long which for purposes of strength we cut three-quarters inch too long and double back on itself, using our adhesive.

Over all this we now stick the second glass plate so as to cover the other completely. So that the two plates will be absolutely parallel we glue a small piece of tinfoil to the opposite side, between the two plates. Fig. 1 may again be referred to to show the whole arrangement in cross-section and plan. The tinfoil is cross-hatched in the drawing, to make the representation more intelligible. In the cross-section the glass plate is marked with diagonal shading while the black indicates the tinfoil. The position of the two clamps is also shown in the drawing.

Now we cut from cardboard or from mica, hard rubber or veneering, two strips ¼-inch wide and 7¼ inches long of the thickness of the plates out of which we are to make our variable condenser. Both strips are glued to the upper glass plate along the longer edges. Fig. 2 represents the arrangement very clearly.

In the lengthwise section they are cross-hatched but less darkly than the others. The reader will now see that the strips act as guide pieces for the movable plate. We must be careful to have them parallel so that the plate will follow a perfectly straight and the same invariable course in entering.

The second coating of tinfoil we place exactly like the first and glue it between the two halves of the third glass plate which has been cut in two pieces across the center. These double plates are glued to the wooden guide strips so that the tongue covers that of the lower coating. This is shown clearly in Fig. 2, together with the connection of the tongue with the insulated clip terminals. The form and size of the movable plates are shown in the left window in Fig. 3. In the middle of one of the long sides we fasten by welding or soldering a strip whose length reaches nearly to the height of the box which is to contain the finished condenser. This

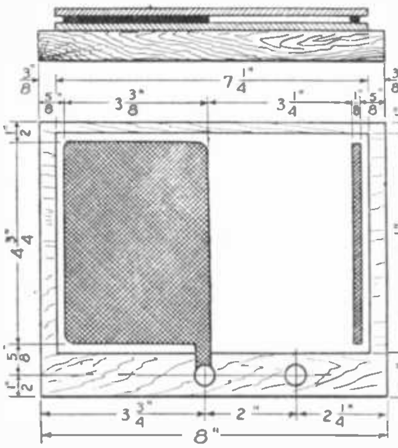


FIG. 1

The above drawing shows the arrangement and constructional details for building the variable condenser. A front as well as a side view is given here.

strip has a small screw for receiving a finger nut which has two indexes on it, or a slot can be made in the strip and can work upon a projection ¼-inch wide which is cut out of the metal and bent upwards at right angles. For the adjusting screw an ordinary one can be used from which the head has been filed off. The screw will be held more securely as the metal plate is thicker, which makes the indications of the nut upon the scales more reliable. As the distance of the coatings from each other, as affecting the capacity of the condenser, depends entirely on the thickness of the glass plate, but not at all on the thickness of the metal plate, we can make the latter thick or thin as we wish.

The maximum capacity of the condenser is reduced by cutting off the movable plate.

The metal plate with its strip we place on the second glass plate so that it reaches about ¼ inch into the interval between the coatings. In Fig. 2 the arrows indicate its position. To the strip we solder a well-insulated copper wire which is wound into a coarse spiral which connects with the second terminal clip. Naturally this clip is insulated.

In the cover of the finished condenser we cut a slot the width of the adjusting screw and 3½ inches long. In each side of the slot scales are placed which can be etched there according to capacity or to wave-length. The complete condenser is shown in Fig. 4.

Greater dimensions for the purpose of giving greater capacity will make the condenser somewhat bulky, but the capacity can be increased by connecting in parallel a fixed condenser or by adding a second coating and a second movable plate.

Our condenser can also be placed very readily in a horizontal as well as in a perpendicular position into any set, if we keep the adjusting slot horizontal, without making it of inconvenient size. The slot can be cut through the covering board or front board of the set, so that nothing is to be seen of the condenser except the button with its indexes and the scale.

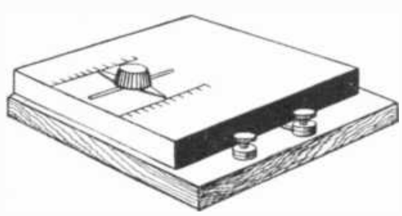
Our condenser has one advantage over many rotary condensers, as the latter are constructed unfortunately in this time of high competition; it is free from scratching, because contact between the plates is impossible. Its capacity also remains absolutely constant, because the distance between the plates cannot be changed, which in rotary condensers can be brought about very often by bending or buckling.

Our sliding condenser shares with circular rotary condensers the peculiarity that the wave-lengths are not evenly spaced through the scale. In rotary condensers equal division for wave-length is obtained by changing the shape of the plates. Instead of making them circular, their contour follows a spiral. Such condensers are often advertised in our papers. We can easily arrange our condenser so that the scale will be divided up equally for wave-lengths. This is done by giving the movable plate the form shown on the right hand of Fig. 3. The angles at the corners are here given arbitrarily; in practice they must be laid out according to the maximum and minimum capacity of the condenser. In general, they cannot be calculated for all cases before cutting and for every condenser they have to be determined by trial.

This can be done as follows: By listening to some waves of known length, or by using a wavemeter, it can be determined how the waves are distributed over the scale. If the divisions come out too uneven, the longer side of the plate is cut off nearly ¼ inch on each side and the trial is repeated. Fig. 3 shows over ¾ inch cut off from one side. When at last an even division of the scale for wave-lengths is obtained, the wave-lengths on other circuits is to be equally divided on the scale. For etching or engraving the condenser scale, all that is necessary at first is to know the wave-lengths for the beginning and end of the scale. Other wave-lengths are then laid out evenly on the scale.

The capacity range of this set is quite broad and may be used any place in the circuit where a variable circuit is used. A condenser of this type is especially efficient for transmission where high voltages are placed across the condenser. If the voltage is unusually high, such as is used in spark transmitting outfits.

The condenser varies with a sideward motion instead of the conventional rotary motion. It is especially adapted for laboratory use and the capacity range may be increased or decreased by the use of external fixed condensers.



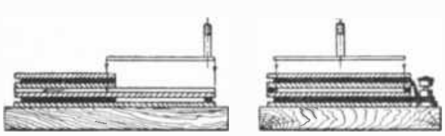


FIG 2

It is clearly shown here how the double plates are glued to the wooden guide strips so that the tongue covers that of the lower coating.

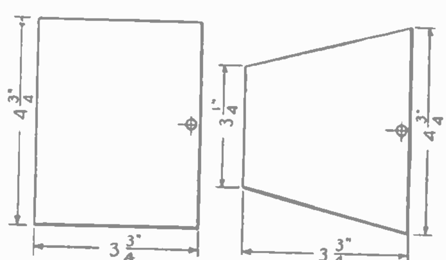


FIG. 3

Attention is particularly drawn to the movable plate. It is best to calculate the minimum and maximum capacity of the condenser. The figure at the left is the form for the fixed plate; the figure at the right the form for the variable plates.

The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

RESISTANCE OF MATERIALS

IN Data Sheet 1-3.4 the fundamental idea of resistance was explained as being merely a "Factor of Proportion" between the voltage impressed on a circuit and the current in it. No account of the material of the wire was undertaken. In 1-3.41 it was shown how the resistance of a conductor may be interpreted in terms of the heat generated in the conductor by the current flowing in it.

Experiment has shown that when a given voltage is impressed across the ends of a conductor, the amount of current caused to flow will be different when the conductor is made of different materials, even though the size and length of the wire are the same in every case. In other words, the resistance of the wire will depend on the material of which it is made.

The simplest way in which to determine the resistance of a wire is to obtain from the table on 1-7 the resistance of the wire per foot. This, then multiplied by the length of the wire in feet will give the total resistance if the wire is made of copper.

In other words, if for No. 22 wire the table gives 16.14 ohms per thousand feet and our wire is 50 feet long, its total resistance to direct currents will be

$$R = 50 \times 16.14/1000 \text{ or } 0.807 \text{ ohms.}$$

Remember this is the resistance to *direct currents* only: it will not in general be the resistance to alternating or oscillating currents. Also, this table applies to wires made of copper. If it be made of any other material, the resistance as obtained above must be multiplied by the figure given in the list below. For instance, if it be made of German Silver, the resistance would be:

$$0.807 \times 19.13 \text{ or } 15.43 \text{ ohms.}$$

Copper	1.00	Silver	0.92
Brass	4.06	Nickel	4.52
German silver	19.13	Manganin	25.00
Phosphor bronze	4.52	Constantan	28.40
Aluminum	1.64		

1-6

The EXPERIMENTER Radio Data Sheets

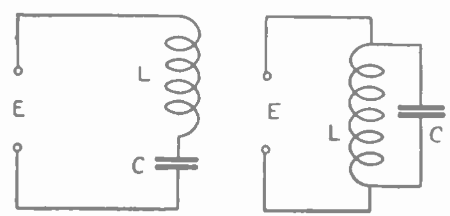
By Sylvan Harris

FUNDAMENTAL TUNING CIRCUITS

IN radio data sheets 10-4 and 10-5 we have discussed briefly the fundamental tube circuits. The next thing to study in connection with radio receivers is the tuned or tuning circuit. Fundamentally a tuned circuit consists of an inductance coil connected in circuit with the capacity of a condenser. The idea of resistance need not be brought into an elementary study of tuned circuits, excepting insofar as to state that if the circuit did not have some resistance, once the current had started to oscillate in it, it would never stop. In other words, the electrons which constitute the current would be in perpetual motion, which, of course, is absurd. It will be satisfactory, however, for the present, to ignore the resistance.

There are two ways in which tuned circuits can be connected, as shown in the figures below. The source of voltage, E, the coil, L, and the condenser, C, may all be connected in series, as at A. This is the series connection. The coil and condenser may be connected together, and the pair then connected in series with the source of voltage. This is the parallel connection.

These two circuits are the fundamental oscillatory circuits in both receivers and transmitters. They will be discussed very minutely as we proceed. The action of the one circuit may be considered almost exactly the opposite of the other. It will be found later on that when the two circuits are properly adjusted with respect to signal voltages which may enter the circuits at E, the parallel circuit will suppress the signal, while the series circuit will allow it to enter.



10-5

The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

WIRE TABLE

Numbers	Diameter in mills.	Weight in Pounds.	Resistance Per 1000 feet.
0000	460.0	640.5	.049 0
000	409.6	507.9	.061 8
00	364.8	402.8	.077 9
0	324.9	319.5	.098 3
1	289.3	253.3	.123 9
2	257.6	200.9	.156 3
3	229.4	159.3	.197 0
4	204.3	126.4	.248 5
5	181.9	100.2	.313 3
6	162.0	79.46	.395 1
7	144.3	63.02	.498 2
8	128.5	49.97	.628 2
9	114.4	39.63	.792 1
10	101.9	31.43	.998 9
11	90.74	24.92	1.260
12	80.81	19.77	1.588
13	71.96	15.68	2.003
14	64.8	12.43	2.525
15	57.07	9.858	3.184
16	50.82	7.818	4.016
17	45.26	6.200	5.064
18	40.30	4.917	6.385
19	35.89	3.899	8.051
20	31.96	3.092	10.15
21	28.46	2.452	12.80
22	25.35	1.945	16.14
23	22.57	1.542	20.36
24	20.10	1.223	25.67
25	17.90	.9699	32.37
26	15.94	.7692	40.81
27	14.20	.6100	51.47
28	12.64	.4837	64.90
29	11.26	.3836	81.84
30	10.03	.3042	103.2
31	8.928	.2413	130.1
32	7.950	.1913	164.1
33	7.080	.1517	206.9
34	6.305	.1203	260.9
35	5.615	.0954	329.0
36	5.000	.0757	414.8
37	4.453	.0600	523.1
38	3.965	.0476	659.6
39	3.531	.0377	831.8
40	3.145	.0299	1049.0

CUT ALONG PERFORATED LINES

The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

THE SIMPLE WAVEMETER

IT was explained, in radio data sheet 1-30, that for any given wave-length the product of the inductance and capacity in a tuned circuit will always be the same. Thus, for a wave-length of 600 meters any of the following combinations of inductance and capacity may be used:

Inductance (microhenries)	Capacity (microfarads)
400	0.00025
200	0.0005
100	0.001
50	0.002

In fact, an infinite number of combinations can be found which will give the same oscillation constant when multiplied. All the combinations above have as their product 0.1, which is approximately the oscillation constant for 600 meters.

It is evident also that when a variable condenser is used with a fixed inductance, every time the condenser is brought back to the same setting the circuit will be tuned to the same wave-length. A simple wavemeter, therefore, is nothing more nor less than a series circuit as shown in Fig. 1, consisting of a point of entrance for the waves to be measured, as at E, and a fixed coil and variable condenser, all in series, with a current measuring device, A. This may be replaced by the simple closed circuit in Fig. 2, for it has been explained in 10-7 that these two circuits are equivalent, when the voltage of the circuit arises within the coil. In using the wavemeter it is brought near the circuit emitting the waves to be measured. A voltage is induced in the coil, and when the wavemeter circuit is tuned to resonance with the waves, the current indicator A registers its greatest deflection.

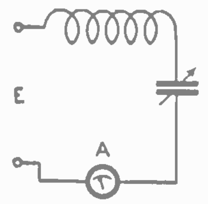


FIG I

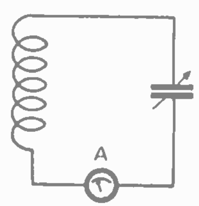


FIG. 2

14-10

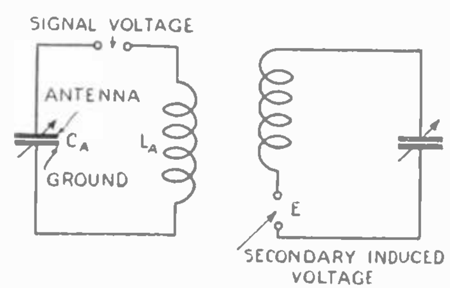
The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

FUNDAMENTAL TUNING CIRCUITS [Continued]

THE simple arrangement of series and parallel tuned circuits was explained in data sheet 10-6. There are many instances in which these two circuits exist in radio receivers, and these will be discussed as we go along. The figure below shows the two most important tuned circuits in a simple receiver. Both of these are the simple series circuits; the antenna circuit consists of the variable inductance coil La connected to the capacity of the antenna to ground Ca, by means of the ground and in series with the signal voltage. This latter is not indicated on the figure. The secondary circuit consists of the coil L connected to the condenser C.

Although at first sight this may seem to be a parallel circuit, it is in reality a series circuit. The voltage impressed on this circuit arises *within* the windings of the coil L, and when such is the case it is to be considered in series with the rest of the circuit. In other words, the secondary circuit can be thought of as *equivalent* to the circuit shown below, in which E is supposed to be the voltage induced *in the windings* of L. The antenna of primary circuit is also shown, the antenna and ground being considered as the plates of a condenser, Ca.



10-7

The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

THE SIMPLE WAVEMETER [Continued]

THE construction of a simple wavemeter that will satisfy all the needs of the amateur experimenter and many of the needs of a full-fledged laboratory, is a fairly simple matter. All the apparatus required to be bought are a good condenser and a thermogalvanometer. The rest of the instrument can easily be built by the experimenter himself.

The condenser should have rather low resistance and should be sturdily built so that its plates will not bend easily. A good dial is required which is accurately marked off and which can be read very closely. The index of the condenser can be made of a piece of transparent celluloid with a scratch on it, extending a little over the divisions on the dial. A geared dial is preferred so that the settings can be made accurately. The capacity of the condenser should be about 0.001 microfarad.

The coil can be wound on a tube of good insulating material, of No. 18, solid D.C.C. copper wire, using double spacing for the turns. If the tube has a diameter of 3 inches, 37 turns of wire will be required.

The condenser is mounted inside a box large enough to hold it, and the terminals connected to binding posts on the box to which the meter and coil can be fastened. The general arrangement can be seen in the photograph, which shows a wavemeter constructed in the Radio News laboratory.

The thermogalvanometer should carry a current of about 100 milliamperes for full-scale deflection. There are several makes on the market which are suitable. The range of the instrument will be from 200 to 600 meters, which covers the whole broadcast range of wave-lengths. When the construction is completed the instrument is ready to be calibrated. The method of making the calibration will be explained later.

14-11

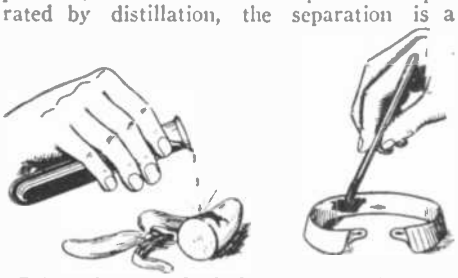
CUT ALONG PERFORATED LINES

Introductory Qualitative Analysis

By J. Edmund Woods

Member of the American Chemical Society

WHEN a turbid liquid is filtered through filter paper, its separation from the accompanying solid matter is a mechanical one, based on the difference in size between the fluid particles and the much larger ones that comprise the solid. When two liquids are separated by distillation, the separation is a physical one, depending on the circumstance that one of the liquids changes into gas at a lower temperature than the other.



Interesting proof of the presence of starch in a banana or in a shirt collar. This test is exceedingly delicate and may be applied to a number of objects where we little realize that starch is to be found.

A third general method of separating substances is through the agency of chemical change, and this we call chemical analysis. Chemical separations are brought about by making from one or another component something entirely different, which is perhaps easier to remove from the other components by mechanical or physical means. To illustrate, if you had a pile of waste paper in which there were several dollar bills, and in some way you were able to convert the bills into fifty-cent pieces, it would be a simple matter then to recover the money, because the silver coins could be sifted from the waste paper. This is analagous to chemical separations, where a change in the constitution of one ingredient often facilitates its removal from a mixture.

Passing carbon dioxide gas through clear lime water. The production of a white precipitate indicates the presence of lime as the insoluble calcium carbonate is formed.

To understand analysis we must appreciate the distinction between *masses*, *molecules* and *atoms*. If you examine a familiar substance such as table salt you find it to be made up of crystalline grains, which are small *masses* of salt. These grains are not the smallest conceivable particles of salt. Each of them can be ground up into finer bits until the whole is an impalpable powder, and no matter how finely the material is ground, its tiniest fragments are still *masses* of salt. Nevertheless, there is a limit to the possible degree of subdivision. This limit is represented by the *molecules* of salt, which are the very smallest particles of it that can exist. Their size is infinitesimal; even if we could isolate one, it would be impossible to see it, and the minute grains you obtain by powdering the substance consist of millions of molecules apiece.

Every molecule of salt is alike, and each one has the same qualities as large mass of salt, but if one of these molecules could be further divided, it would give two particles unlike each other and having none of the qualities of salt. These particles are called *atoms*, one of them being an atom of the element *sodium* and the other an atom of the element *chlorine*. All substances are made up of molecules and all molecules are made up of atoms. If the atoms in a molecule are alike, the molecule belongs to the class called *elements;* if the atoms in a molecule differ, the molecule belongs to the class called *compounds*.

In chemical analysis we aim to break up the molecules that we have, and from their atoms construct other molecules of different characteristics. Hence we say that a *chemical change* is one that concerns the *atoms* of a substance, whereas a *physical change* is one that affects the *molecules* without disturbing the atomic arrangement in them. *Mechanical changes* affect whole *masses* of molecules rather than individual ones. Thus a filtration of solid from liquid is *mechanical*, for only *masses* of the solid molecules will be retained by the paper. A distillation of a liquid is *physical*, for every *molecule* of the liquid is made to change individually into the gaseous state. But if one solution added to another causes a change, say, in color, the effect is chemical, for it indicates that molecules of a new substance have formed from molecules of the old by a rearrangement of *atoms*.

Our preliminary practice in analysis will deal as far as possible with materials common to the household, not only because this will cut down expense, but also because the nature of such materials is of particular interest to everybody. As chemical reagents you will need the following to begin with: Hydrochloric acid (sometimes called muriatic acid); some strips of red and of blue litmus paper; iodine; sodium thiosulphate (also known as photographers' "hypo"); silver nitrate; marble chips or chalk; ferric chloride; Fehling's solution. All of these can be purchased at any drug store, and an ounce of some and much less of others is plenty. Hydrochloric acid, which can be used in so many subsequent experiments, should always be on hand. Fehling's solution can be made up at home if desired. It consists of two parts, one being a solution containing 70 grams of copper sulphate to a liter of water (or 2½ ounces to a quart) and the other containing 346 grams (or 11½ ounces) of Rochelle salt mixed with 50 grams (or about 8 ounces) to a liter of water. If you have not a graduate which shows cubic centimeters and liters, consider a quart as nearly the same as one liter.

Half fill a test tube with clean water and add a few crystals of iodine, shaking and warming the tube to hasten the dissolving. Then apply a drop of the liquid successively to pieces of bread, cake, banana and to a little starch. Use a drop on the inside of an old collar. In each case the spot touched by the iodine will turn almost black, though the actual color is blue, as you can prove by mixing some starch with a large volume

Another version of the lime water experiment. Here the lime water is spread on a sheet of glass and placed over a jar in which carbon dioxide gas is evolving; or even a jar full of the gas will answer. The thin layer of the liquid turns whitish.

of water before adding the iodine solution to it. This test identifies starch in any substance that may contain it. Apply a solution of sodium thiosulphate to any iodine stains that may have got on your fingers and they will disappear. This treatment causes a chemical change by combining the iodine with the sodium.

A large test tube or a small bottle is to be fitted with a cork that has a hole bored in it. Insert a short piece of glass or metal tubing in the cork to fit tightly. Then connect a longer tube to the short one by means of soft rubber tubing, and you will have what chemists call a simple gas generator. Next make a solution of slaked lime by shaking some common lime in a small bottle of water. Let the solution stand for a while to settle. Pour off the clear solution if possible, taking care that it does not carry any suspended solid matter with it, as this would have to be filtered out. Half fill a test tube with this clear lime water. Now put a few chips of marble in the generator, and pour in a little dilute hydrochloric acid. Quickly replace the cork and insert the long tube in the lime water as the illustration shows. A vigorous effervescence in the bottle will be accompanied by rapid bubbling of gas through the lime solution, and a white cloud of solid particles will appear in the solution. The solid is a *precipitate* of calcium carbonate, which is chemically identical with the marble you used in the generator. What then is gained by the experi-

Precipitating silver chloride with silver nitrate. Note the dark bottle frequently used for preventing light from acting on the clear solution.

ment, since it reproduces the same compound you started with? The gain is in the identification of carbon dioxide as a constituent of the marble, for no other gas will produce this precipitate in a lime water solution. Carbon dioxide is a constituent of all carbonate compounds, of which there are many others besides marble. Calcium carbonate is represented by the formula $CaCO_3$, while carbon dioxide is CO_2. When calcium carbonate is treated with hydrochloric acid or some other acid, a reaction ensues in which carbon dioxide gas is set free from the calcium carbonate, and if the gas is conducted into a solution of calcium hydroxide, $Ca(OH)_2$, which is lime water, it reacts with the calcium hydroxide and produces calcium carbonate again. As the latter is insoluble in water, it deposits or precipitates in the solid state. Chemists indicate a change like this by an equation:

$$CO_2 + Ca(OH)_2 = CaCO_3 \downarrow + H_2O.$$

Repeat the experiment using instead of marble chips, some chalk, washing soda, baking soda, tooth powder or some egg shells that have been heated previously in a flame. Burn a small piece of wood and subject the ashes to the same test. All of these materials are carbonates or contain carbonates, as demonstrated by the fact that on treating them with an acid they give off CO_2, which can produce a white precipitate in lime water. You can make the test without the apparatus described by wetting a flat piece of glass with lime water and placing the wet surface over the mouth of a bottle in which acid has been poured on the material to be

Flame test using an iron wire which is applicable for sodium or potassium and many other substances. Platinum wire was used before it was so expensive and is still much the best.

tested. If the specimen is a carbonate, carbon dioxide will rise from it and react with the calcium hydroxide solution on the glass plate.

Make a solution of sugar in water, add a drop of hydrochloric acid and warm. In a test tube mix equal quantities of both kinds of Fehling's solution and add the sugar water. Gradually bring the solution to a boil and note the striking color changes that take place. Cane sugar is made up of two simpler sugars, one of which is glucose. Fehling's solution serves to detect glucose by the appearance of a red precipitate, when anything containing glucose is boiled with it. The idea of warming the sugar with acid beforehand was to break it up into glucose and another simple sugar called fructose. The same thing takes place in your mouth when you eat candy or any other food containing cane sugar, though here the simplifying agent is the saliva, not an acid.

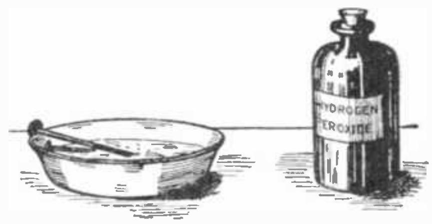
Make a dilute solution of silver nitrate, which is to be kept in a dark place, as light decomposes it. Add a little of this solution to some table salt dissolved in water and you will obtain a beautiful white precipitate. This is silver chloride, an insoluble compound that forms whenever silver

Experiments with vinegar; vinegar is dilute acetic acid and it is so dilute that it is preferable to secure some of the real acid from a druggist rather than to use the household condiment for the experiment.

nitrate comes in contact with a chloride. Pour some ammonia water into the test tube and observe how the precipitate dissolves again. The test is used to detect chlorides, and as common salt is sodium chloride, it responds to it. Try the same test on small portions of hydrochloric acid, which may also be called hydrogen chloride, and on salammoniac, which is ammonium chloride. Next apply the test to a specimen of drinking water. You will probably get a faint cloudiness when the silver nitrate is added, as chlorides are very prevalent in natural waters. When a considerable amount of chloride is found in drinking water, however, it is a danger sign, as this indicates possible contamination with sewage.

Fasten a piece of heavy iron wire in a short glass tube by melting the glass around one end of the wire. Then holding the wire by its glass handle, insert its other end in the blue flame of a gas range or a Bunsen burner. After a few minutes the flame around the wire will cease to be discolored, showing that the wire is clean. Then dip the wire into some common salt and hold it again in the flame. An intense yellow coloration will be imparted to the flame, which is characteristic of all sodium compounds. By this and the foregoing test you have demonstrated that common salt contains both sodium and chlorine. Actually it contains nothing else, if pure. Common salt is sodium chloride, as was stated at the beginning of this article. Its formula is NaCl, which stands for a molecule of the compound, the Na representing an atom of sodium and the Cl an atom of chlorine. Restaurant proprietors often mix a little starch with the table salt in summer so that the starch will absorb moisture and keep the salt dry. It will be interesting to test various specimens of restaurant salt with iodine solution at your next opportunity. Try the flame test on the wood ashes you prepared. Here a violet flame coloration indicates the presence of potassium.

Pour some vinegar into a shallow dish and dip a piece of blue litmus paper into it. The paper will turn red, showing that an acid is present in the vinegar. The acid is called acetic acid, and it gives the vinegar its pungent taste and odor. Now make a strong solution of washing soda and test it with red litmus paper. The paper will turn blue, showing that the solution is alkaline. Alkalies are the opposites of acids chemically. Pour small portions of the soda solution into the vinegar, testing with blue litmus paper after each addition, and you will soon reach a point where the mixture is no longer able to redden blue litmus. The soda has neutralized the acetic acid, and sodium acetate has been formed in consequence. Filter the liquid to clarify it, and then add a solution of ferric chloride. If ferric chloride is not easily obtainable, you can make some by dissolving part of an iron nail in hydrochloric acid with the aid of heat, and adding a drop of hydrogen peroxide to this solution after diluting it. Ferric chloride will produce ferric acetate when mixed with a solution of sodium acetate,



Experiment with ferric acetate; an experiment not quite as familiar as those hitherto described. Hydrogen peroxide is used as the oxidizing agent.

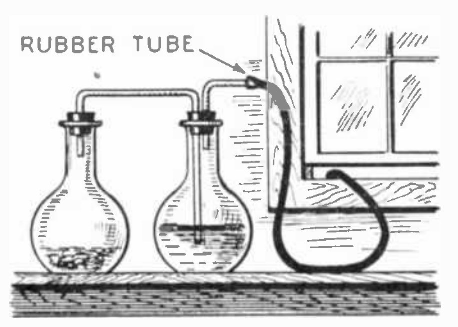
and this gives a red color to the liquid. On boiling, a reddish brown precipitate appears, which confirms the presence of acetates.

Many other interesting and useful tests could be described if space permitted. In the next article on analysis some experiments for the identification of common metals will be shown. A few hundred years ago if any experimenter had carried out such reactions, and by means of them told what substances were made of, he would most likely have been accused of sorcery and put out of the way. In this day and age we all know chemical analysis is honest and reliable, yet the vast majority of people have no conception of how the chemist does his work, and to them it is as much magic as ever.

Gas Generating Kink

THE experimenter often has occasion to generate some particular gas quickly and simply, without wishing to go to the bother of connecting up the regular gas-generating apparatus, or putting the apparatus to work in a forced draft, or "hood." And many laboratories, too, are not equipped with a ventilator "hood"; and so the generation of chlorine, hydrogen sulphide and other disagreeable gases proves a very disagreeable operation.

For this problem there is a quick and simple solution that does away with all of this bother. For a generating apparatus, simply connect up two flasks as shown. Connect to the outlet from the second flask a long rubber tube, a cheap common red rubber hose, procurable at any drug store.



An arrangement to take the place of an evaporating chamber. Here the obnoxious gases evolved are taken out through the window into the open air; a very simple and effectual arrangement.

Thus the surplus, undesired gas may be carried out-of-doors by passing the end of the tube under a window or door. The writer has found this very efficient for conducting away gases from his laboratory situated in the basement. Without this device the odors and gases soon penetrate the whole house.

Quite an improvement could be effected by placing the board under the window sash with a hole bored through it, fitting the hose tightly. This applies to the ordinary window. In the case of a door this improvement would not apply, because there is no place to put such a board.

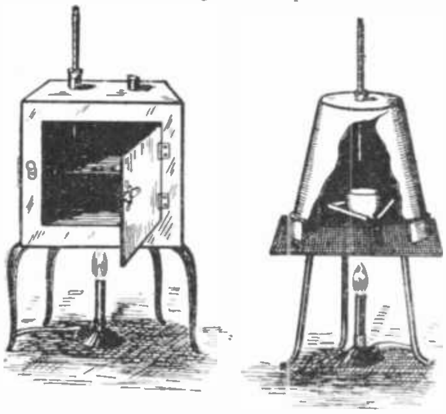
Regard should also be had to the direction of the wind.

Contributed by CARLYLE WEISS.

Chemical Manipulation

By T. O'Conor Sloane, Ph. D.

THE chemist has frequent occasion to use the appliance called the air-bath. This is a box with an opening and door, generally constructed like a little cabinet, perhaps 8 inches high and 10 inches wide and 6 or 8 inches deep, with a perforated shelf and an aperture for a thermometer to be introduced through the top.

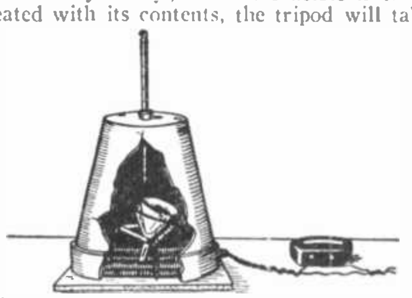


The air bath or drying chamber. On the left is shown the regular apparatus while on the right an inverted flower pot with thermometer, the whole resting on a plate of metal forms an excellent substitute for work on the small scale. The writer has used his apparatus a great deal and found it eminently satisfactory.

A gas burner placed below it keeps it hot and the temperature is regulated by turning the gas on or off. This is often done entirely by hand and it is to some extent an annoying thing to have to watch it closely, keeping the temperature within 7 to 10 degrees Centigrade of a desired point.

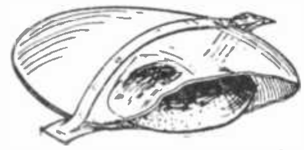
An excellent system is to heat it by electricity; this may be done by putting a coil of heating wire such as we find in the electric flat or laundry iron, in it, supporting it on insulating blocks, if the air bath is made of metal, as is usually the case.

One great point is that anything to be heated should not rest upon the bottom, but should be supported in the middle, a good distance from the base. This can very conveniently be done by using a triangle, preferably a pipe stem triangle, and bending its legs downwards so as to form a tripod. If a precipitate is to be dried along with the filter paper, the tripod will hold a small funnel very nicely; or if a crucible is to be heated with its contents, the tripod will take care of this, too. In this way local heat is avoided and a sort of average is struck, and as a refinement the bulb of the thermometer may be kept very close to the crucible or funnel.



The flower pot air bath is heated by a resistance coil borrowed from a flatiron or other object. If the flower pot rests on a piece of asbestos board, no insulation for the coil will be required. An ammeter is used to watch the current.

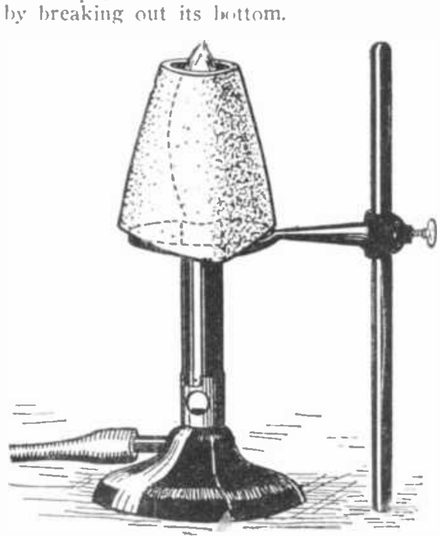
Although no chemist likes to do it, precipitates often have to be weighed along with the filter paper, and for these the heating in the air bath is absolutely essential to get rid of every trace of moisture. After the filter paper has been dried in a funnel perhaps, it may be very carefully folded and placed between two watch glasses, taking care that they do not fit air-tight, and heated while thus covered up, and watch glasses and all are weighed.



Watch glasses clamped together for holding a filter paper to be dried. The glasses are shown broken away in order that the filter paper may be seen; of course, they are really not broken.

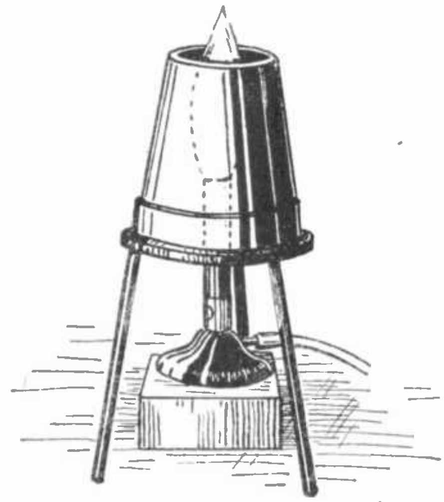
A simple modification of the air bath is really a capital thing and has been used by the writer a great deal. It can be made from a flower pot and a plate of iron. The flower pot is inverted on the plate and gives what it is not too much to call a thoroughly practical air bath. The hole in the bottom of the pot may be filed out a little if it is rough and a perforated cork with a thermometer thrust through it is pushed into this hole. It will be seen that we have the elements of an air bath, very compact, costing but a few cents, and as good as the quite expensive copper ones.

Sometimes it is desirable to fit a short chimney into a Bunsen burner. This makes the flame a little more intense and steady and undoubtedly produces a higher temperature. These chimneys can be bought, made of metal, open ended truncated cones, perhaps 2 inches high and 1½ inches in diameter. An excellent substitute for them can be made from what is known as the Hessian crucible, such as used by assayers. These are rather soft in substance, although they are infusible except at very high heat. It is an easy matter to make a hole through the bottom; the end of a file or cold chisel may be used to do this with the exercise of a little patience, and when a hole of sufficient size has been made and dressed out smoothly, it gives really an admirable chimney for the Bunsen burner. A very small flower pot can be made to do this service by breaking out its bottom.



A Hessian crucible has its bottom punched out and worked up smoothly so as to give an excellent chimney for a Bunsen burner.

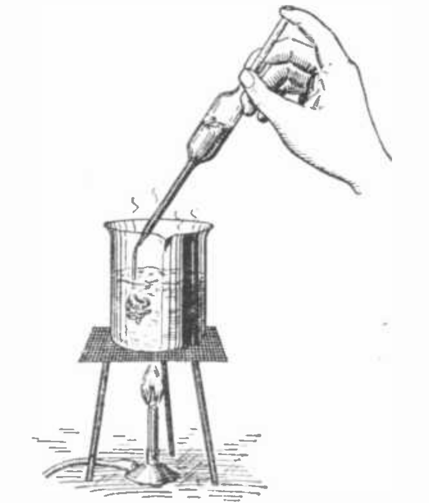
This operation and all the minor operations in preparing this home-made apparatus should be done nicely. There is nothing so offensive, in what has been termed home-made apparatus, as a clumsy piece of work. It is wonderful how much can be done by simple appliances, and a great exemplar of this was Faraday. His lectures which were one of the great attractions of London at the Royal Institute were done with the simplest possible apparatus, and people instead



A small flower pot is made to serve the same purpose, a chimney for a Bunsen burner. Such a chimney makes the flame much steadier and increases the heat.

of looking at a lot of glassware and implements of brass, saw the combination of manual skill and high intellect dividing the technical and demonstrative part of the lectures.

A chemist has a great deal of filtering to do, but occasionally a substance is encountered which will not filter. Such a substance is albumen, and this is brought to the writer's mind by the analysis of dried blood referred to above. A solution of dried blood in water will not go through a filter paper. So the way it is treated is to



Precipitating albumen in hot water; by dropping it in as shown it collects in a clot or clots in the center and then the water can be filtered from it. The original solution is unfilterable.

place a weighed quantity in a beaker with a measured quantity of water, and by standing and stirring a perfectly uniform solution is obtained. Water is now boiled in another beaker and kept in ebullition and 50 or 100 cubic centimeters, as the case may be of the albumen solution are withdrawn in a pipette, and discharged in a body into the boiling water.

The effect of this is that the albumen coagulates in a sort of lump; the water is entirely free from it, and it can now be filtered out on a filter paper which has been previously weighed and dried in the air bath at about 110 degrees Centigrade.

Laboratory Reproduction of the Solvay Process

By Earle R. Caley, B.Sc.

I. *Introductory*

VIRTUALLY all of the most useful compounds of sodium with the elements (namely: sodium hydroxide, commonly known as caustic soda, sodium bicarbonate, otherwise called baking soda and sodium carbonate, one form of which is common washing soda) are made in this country by the Solvay Process. This important process of the chemical industries was invented by a Belgian chemist, Ernest Solvay, and is conducted commercially on a vast scale in a number of plants engaged in making these important products.

The fundamental source of all compounds of the element sodium, which play a large role in modern civilization, is common salt, known chemically as sodium chloride. Sodium chloride is not only in the waters of the ocean but occurs abundantly in mineral deposits as rock salt, and in the water of salt wells and in some inland seas. It is cheaply obtained but in itself has a somewhat limited use, while nearly all other sodium compounds must be obtained from sodium chloride. The Solvay Process, which accomplishes this transformation cheaply, is an interesting example of the production of a desired finished product from a raw material. It may, moreover, be conducted on a miniature and experimental scale and the experiment in question detailed below is both instructive and easily performed.

The fundamental step in the Solvay Process lies in converting sodium chloride into sodium bicarbonate by acting upon a strong salt brine by ammonia and carbon dioxide gas. Industrially, this is done by saturating a strong brine with ammonia gas, forming ammonium hydroxide, and then allowing this brine to trickle down towers through which a stream of carbon dioxide passes. Sodium bicarbonate then separates as a white solid which is collected and dried. The ammonia is recovered from the waste liquors by treating them with slaked lime formed by burning limestone, the carbon dioxide from which is used in the process. The process once started is arranged as a continuous one and the only raw materials used up are salt and limestone. In the laboratory experiment described below the carbon dioxide gas is obtained in another way as a matter of convenience.

To get sodium carbonate from the sodium bicarbonate it is simply heated gently to drive off water and carbon dioxide leaving the sodium carbonate behind. Caustic soda is either obtained by the electrolysis of a salt solution or as described below by treating a solution of sodium carbonate with slaked lime, filtering off the calcium carbonate which is formed and concentrating the solution until the solid sodium hydroxide (caustic soda) separates.

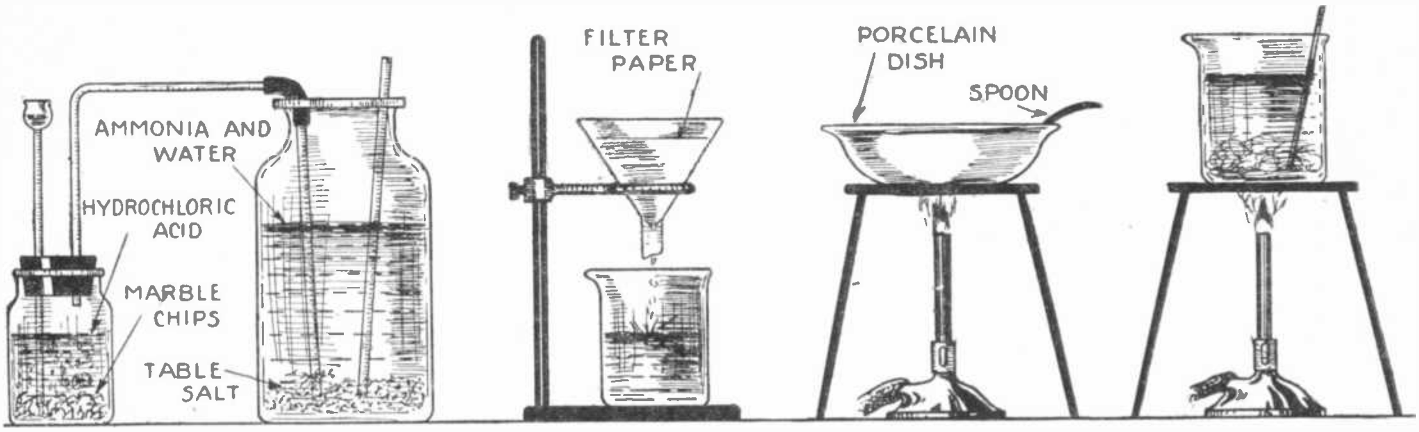


FIG. I FIG 2 FIG. 3 FIG. 4

In the production of sodium bicarbonate, which is baking soda or sodium carbonate which is washing soda, the Solvay process is much used. (Fig. 1) carbon dioxide is passed through a solution of ammonia and ordinary table salt in water. The four ingredients—water, sodium chloride, ammonia and carbon dioxide—react to form sodium bicarbonate and ammonium chloride. The former of these products appears as a white precipitate which is collected on the filter paper (Fig. 2) after the solution is filtered. This sodium bicarbonate can be made to yield sodium carbonate by heating (Fig. 3). By boiling together with slaked lime, sodium carbonate will give sodium hydroxide or caustic soda (Fig. 4).

II. *Experimental Part*

Experiment I

The Preparation of Sodium Bicarbonate

The raw materials required for this experiment are, a small quantity of ordinary table salt, a solution of strong ammonia (household ammonia is quite satisfactory), a quantity of marble chips or pieces of limestone for the generating of carbon dioxide and a quantity of commercial hydrochloric acid for the same purpose.

The apparatus required is shown in Fig. I and is quite easily obtained and set up. A wide-mouthed 250 c.c. bottle provided with a well-fitting double-holed rubber stopper through which passes a thistle tube and a gas outlet tube serves as the gas generator. The gas outlet tube passes to the bottom of a large beaker or large bottle of a pint or more in capacity. A long glass stirring rod reaches to the bottom of this absorption beaker or bottle.

The solution for the absorption bottle is prepared as follows: 100 grams of table salt are roughly weighed out and placed in the bottom of the bottle. 200 c.c. of water is now added along with 150 c.c. of a strong solution of ammonia. The mixture is then stirred until all the salt is dissolved. As soon as this has been done the generator is set going and the absorption commences.

This generator bottle is charged by filling it half full of marble chips and then pouring dilute hydrochloric acid through the thistle tube until a fairly rapid stream of gas is passing into the absorption bottle. To hasten the process of absorption and the formation of the sodium bicarbonate the solution should be vigorously stirred from time to time as the gas bubbles through it. The absorption will be completed in an hour or two. The end of the action is shown when the gas bubbles passing through the solution no longer decrease in size as they come to the top.

A white suspended precipitate which imparts a milky appearance to the solution is now to be seen. This is the sodium bicarbonate. To separate this from the mother liquid, the entire solution is passed through a filter paper in a large funnel as shown in Fig. II. A small amount of ice-cold water should be poured over the solid upon the filter paper after the liquid has run through in order to free the sodium bicarbonate from impurities. Only a small amount of this wash-water should be used since a larger amount would cause a considerable loss of the solid due to its solubility in water.

The filter paper filled with the wet solid is then placed in an oven heated to 110° C, and dried for several hours. At the end of this time the pure white compound formed, which is a fairly pure form of sodium bicarbonate or baking soda may be placed in a clean, dry and properly-labeled bottle for future use.

Experiment II

The Preparation of Powdered and Crystallized Sodium Carbonate

Anhydrous sodium carbonate, *i.e.*, sodium carbonate containing no water of crystallization, may be easily obtained by simply heating for some time a portion of the sodium bicarbonate obtained in the last experiment at a temperature just below a red heat. To do this properly a quantity of the dry salt should be placed in a porcelain evaporating dish or casserole and heated with a Bunsen burner, as shown in Fig. III.

The powder should be stirred from time to time with a spoon or spatula. Care must be taken that the heat is not allowed to be sufficient to melt the salt, since this spoils the preparation. After no more water or carbon dioxide gas is evolved from the heated powder (this may be told from the cessation of small holes like miniature geysers, in the powder caused by escape of steam and gas) the preparation is finished.

In case the salt is wanted in the form of crystals, which are known in commerce as sal soda or washing soda, a quantity of the powdered sodium carbonate obtained above, is placed in a beaker and dissolved in the least necessary amount of boiling water. This solution is then allowed to cool down to room temperature and is placed in a refrigerator or ice box for a short time.

(*Continued on page* 490)

Some Useful Laboratory Hints

By Eugene W. Blank

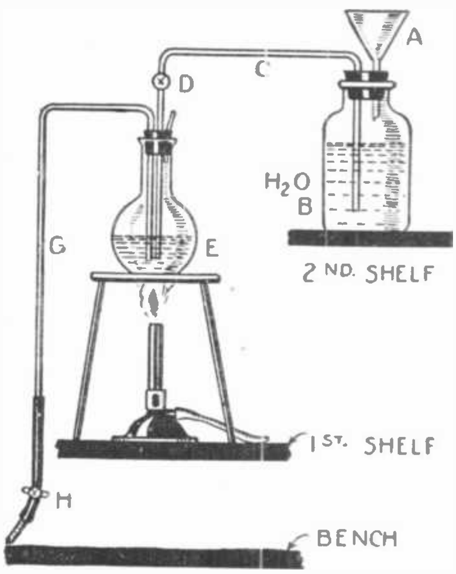
MANY times in chemical work, when washing a precipitate or preparing a solution, a continuous slight stream of hot water is needed. The average experimenter is not blessed with a laboratory containing hot water on tap, so the following apparatus serves as an admirable substitute:

Referring to the diagrame (B) is a large bottle containing the water supply which can be replenished without disturbing the system, and is situated on a shelf above the laboratory table or desk. It is closed with a stopper containing a funnel and tube (C). The latter tube conveys the water to the flask (E) where it can be heated by the burner. From this flask the tube (G) leads to the outlet for the hot water.

The action is simple; by opening stocpcock (D) flask (E) can be filled with as much water to be heated as will be needed. When the water has reached the right temperature, it can be conveyed to the outlet by opening the cock (H). The funnel serves to add water to the apparatus without disconnection. A steady stream of hot water can be secured by heating the water in the flask and then opening the outlet and inlet tube so that as fast as the hot water is used, cold is admitted to be heated.

II

Very often in the laboratory a definite amount of a solution is to be introduced



Arrangement for the chemist's laboratory for maintaining a supply of hot water where such cannot be obtained from the plumbing.

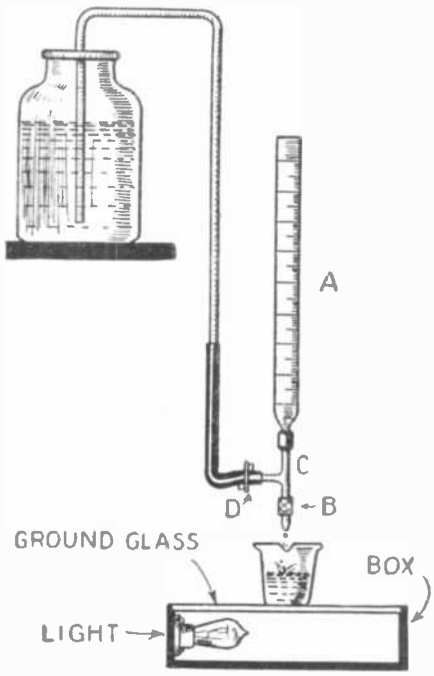
into a container. This can be done by means of a burette, but the constant repetition of filling the burette at its top is likely to prove tiresome. To overcome this the following simple apparatus can be constructed of odds and ends usually found in the laboratory.

As is shown in the diagram T-tube (C) is attached to a burette by a rubber connection. To the lower end of the T-tube is attached a stopcock and capillary tube, while to the side tube is attached a long tube which leads to the supply bottle. The burette is used as any ordinary burette would be, but to refill it, it is merely necessary to close its own lower cock and to open the stopcock (D) and then to close it when the solution has filled the tube.

To make the graduations on a burette more easily seen, rub it with some graphite powder and wipe off the excess.

III

When making determinations it is sometimes necessary to accurately observe the faint color imparted to the solution by an indicator. To facilitate this, insert an electric light bulb in a box and cover the opening with a plate of ground glass. Now by placing the beaker containing the sample on



This shows a method of supplying a burette with solution without the annoyance of pouring it in at the top. The beaker underneath the burette is supplied with light through a ground glass plate on which it stands, for the observation of color changes.

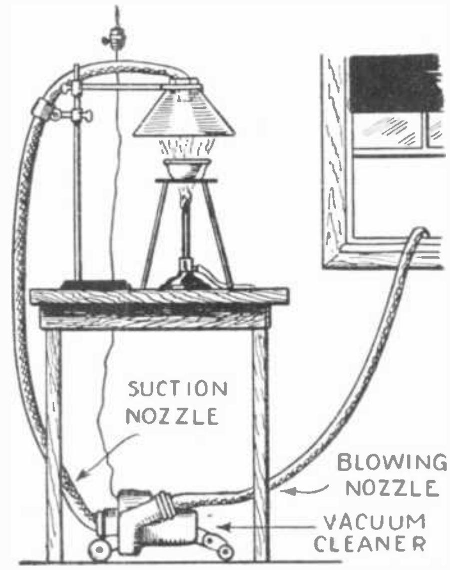
this glass, slight variations in color can be observed.

Home-Made Hood

By William Morgan

FOR some chemical experiments such as burning sulphur, producing acid fumes and odors, a hood is needed to carry away the fumes given off by the chemicals in the experiment. Not having one of these necessary pieces of laboratory apparatus, I purloined a vacuum cleaner out of home cleaning supplies and used it, and I refuse to part with it for the best hood that ever was, ever will be, or is at the present time—my arrangement is the best in the world.

The suction apparatus included with the vacuum cleaner when bought consists of an



The vacuum cleaner in the laboratory; this household appliance is made to take the place of an evaporating chamber.

aluminum nozzle and a rubber hose and the blowing apparatus consists of the same hose and another nozzle.

The hose is connected to the blowing side of the vacuum cleaner and placed so that the end will be out in the open air, *i. e.,* outside the window; or if the laboratory is in the celler, it can be placed in the furnace chimney or in the opening for the draft.

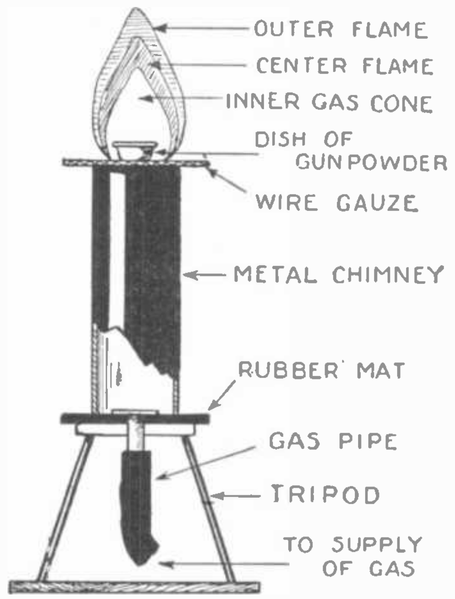
Then purloin the garden hose, connect it to the suction side of the vacuum cleaner and place over the laboratory workbench or table and attach a large tin or paper funnel to the hose. Turn on the electricity and you can experiment to your heart's content with this home-made hood.

Strange Gunpowder Phenomenon

THE following stunt will open the eyes and make the experimenting enthusiast scratch his head.

On a three-legged iron stand place a piece of asbestos board having a hole in the center. A length of rubber gas pipe is attached to the hole in the asbestos, while the other end is coupled to a source of ordinary illuminating gas. Now over the asbestos place a cylindrical metal chimnew open at both ends the length being about seven inches and its diameter about three and one-half inches. Set a sheet of wire gauze over the open end of the chimney.

Directly above the *center* of the metal *cylinder on the wire gauze* set a small dish



Gun powder in the middle of a gas flame is unaffected thereby; the interior of the flame is not hot enough to ignite it.

of gunpowder. Now turn on the gas and hold a lighted taper about ten inches above the dish of gunpowder. There will be a sudden flash, the illuminating gas being kindled and burning above the gauze, but the gunpowder will not take fire. This is a curious situation as the *gunpowder* is in the center of the flame *but does not burn.*

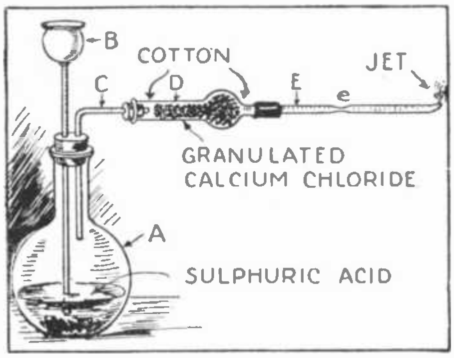
Turn off the gas and apply the taper to the gunpowder. There will be a sudden flash indicating that the gunpowder has ignited. 'S' funny, huh?? Well, here's the explanation. The gas flame is composed of three distinct parts, as shown in the diagram. Within the flame is unburnt gas, having a comparatively low temperature; the center is the light emitting flame having a higher temperature and the third and outer flame is the product, the complete combustion of the carbon particles having a higher temperature than that of either of the other two flames. Hence, the temperature of the innermost or first cone is not high enough to kindle the gunpowder which is placed in it.

Contributed by Simon Liebowitz.

The Chemical Detective

By Leslie R. Raymond

PROBABLY some of our experimenters have read of the part played by the chemist in criminal cases where blood stains were examined, cases of poisoning where the stomach of the victim was examined to learn the cause of his death and probably have wondered just how these things were determined. I shall give here a few of the most common tests which are used in this class of work and hope that they will prove of interest to at least some of you.



A simple Marsh's apparatus for detecting the presence of arsenic. This test is so extremely delicate that it has sometimes led to wrong conclusions.

The Benzidine Test for Blood Stains

First we must make up a solution of benzidine in glacial acetic acid. Only the purest quality of benzidine is used, and the acetic acid must be of recognized purity and glacial (about 99.5% strength). Weigh one gram of the crystallized benzidine and dissolve it in eight and one-half cubic centimeters of the glacial acetic acid. When completely dissolved, add to the solution seventeen cubic centimeters of the best quality hydrogen peroxide. We will suppose that the stains which are suspected are on a piece of cloth. Lay this cloth on a board or table and place over the stains a piece of clean, white blotting paper. Now wet the blotting paper with the benzidine solution and press it down firmly on the suspected blood stain for about ten seconds. At the end of this time lift the blotting paper and examine the part which was in contact with the stain. If the stain was a blood stain, the blotting paper will be found to have turned blue. If the paper has not turned blue, you are safe in assuming that the stain was not one of blood.

Marsh's Test for Arsenic

Arsenic is a poison which is quite frequently used and is very dangerous since only small doses are required to produce death, and in the form usually met, white arsenic (arsenious oxide, As_2O_3) is tasteless. Obviously, when found in very small quantities, a very sensitive test must be used, and Marsh's test fills this requirement admirably. If anything, it is too sensitive.

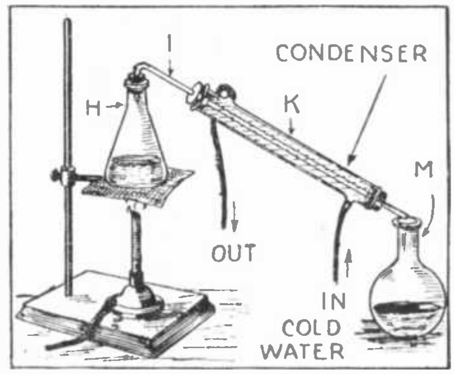
The material under examination may be a food, vomit, or even a stomach and must be examined thoroughly for scales of metallic arsenic or the white grains of the oxide. After a preliminary treatment which may show indications of some other poison, the sample is tested for arsenic as follows: An apparatus is assembled as shown in the figure, for the generation of hydrogen by the action of zinc on sulfuric acid. A small amount of metallic zinc is placed in the flask (A), the two-hole rubber stopper is inserted carrying a safety tube (B), and a short, right-angle glass delivery tube (C). (D) is a drying tube filled with granulated calcium chloride which is used to absorb moisture and thus dry the gas as it passes through. The second tube (E) is of hard glass drawn out at (e), and to a jet at (f).

A small amount of dilute sulfuric acid is added through (B), and after enough hydrogen has been generated to drive out *all* of the air from the apparatus, the gas is ignited at (f) where it will burn with an almost colorless flame. A piece of cold porcelain is held in this flame and a Bunsen burner is lighted and placed under the constriction (e), which is heated to redness. If no black spot appears on the porcelain after several trials, and the tube at (e) shows no deposited mirror of arsenic, the materials may be pronounced free from arsenic. Now add the solution to be tested through (B), being careful not to force any air into the flask in doing so. (For experimental purposes a milligram or so of arsenious oxide dissolved in a cubic centimeter or two of sodium hydroxide solution will be satisfactory.) Now repeat the test with cold porcelain lighting the escaping gas, and keep the constricted point at (e), at a red heat. A mirror of metallic arsenic will be deposited on the interior of the tube at this point and a spot of lustrous black will form on the cold porcelain, though possibly not at the first trial. This stain is easily soluble in a solution of sodium hypochlorite and sodium chloride, if arsenic. The zinc and sulfuric acid must first be tested for arsenic. Notice especially the characteristic odor of garlic.

Detection of Methyl (Wood) Alcohol

In these days of prohibition and the flourishing business of bootlegging, the chemist is often called upon to determine whether a liquid contains the deadly wood alcohol.

The liquid to be examined must first be concentrated by distillation. About 100 cubic centimeters of the sample is placed in the flask (H), which is connected to a condenser (K) by the glass delivery tube (I). A vessel or flask (M) is placed beneath the lower end of the condenser to receive the distillate and the water jacket of the condenser is connected to a supply of cold, running water as shown by means of rubber tubing. When all is in readiness, the liquid in the flask is boiled gently until about 25 cubic centimeters of distillate have been collected in the receiver (M). Now take one cubic centimeter of this distillate and add to it about eight cubic centimeters of distilled water. Mix thoroughly and pour about five cubic centimeters of this mixture into a test tube and place the test tube in a beaker of cold water.



Distillation apparatus for testing for the presence of wood alcohol, of special interest at the present time.

Take a short piece of bare copper wire and coil one end into a spiral. Heat this spiral to redness and plunge it into the liquid in the test tube, repeating several times. Now boil the contents of the test tube until no odor of acetaldehyde is apparent. (This aldehyde has a suffocating odor.) Next cool and add one drop of a solution, made by dissolving one-half gram of resorcinol in nine and one-half cubic centimeters of distilled water. In another test tube place about two or three cubic centimeters of concentrated sulfuric acid and pour the alcoholic solution from the first test tube into the second, allowing it to run slowly down the side so as not to mix with the acid. If wood alcohol is present, a rose-colored ring will appear where the two liquids come together. This experiment may be tried by diluting a small quantity of wood alcohol so that only a fraction of a drop is present when tested.

Handling Phosphorus Sticks

IF a stick of phosphorus is placed in a solution of copper sulphate, it will acquire copper coating. With this copper coating the phosphorus is perfectly safe to handle, and even if it dries off, will not burn.

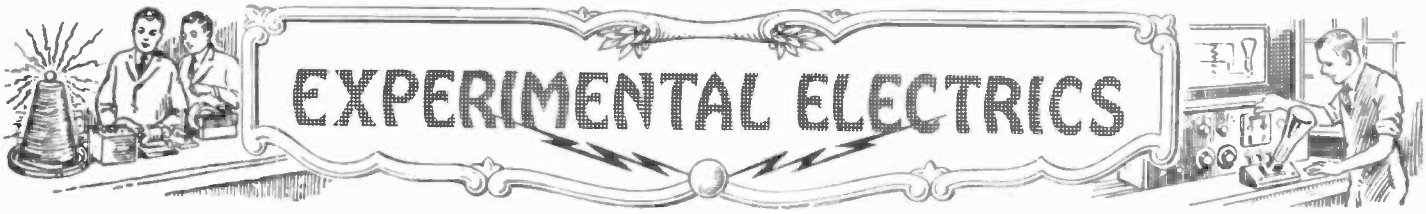
When the phosphorus is to be used, the copper coating should be scraped off, holding the same under water. Only the exposed phosphorus will be active, so in this way monograms, initials, words, etc., can be scratched on the sticks of copper-coated phosphorus, and they will be luminous and shortly after they will burn with the ordinary phosphorus blaze.

A method of preserving phosphorus in the air without any danger of spontaneous ignition. A very simple experiment and one of considerable interest.

An interesting variation on this experiment would be, after scraping the initials as described, which of course should be done under water, to dry the apparatus quickly and rub oil over them. This would operate to prevent the phosphorus igniting, yet would not destroy the luminous effect. Simply immersing the phosphorus in the copper sulphate solution produces the coating.

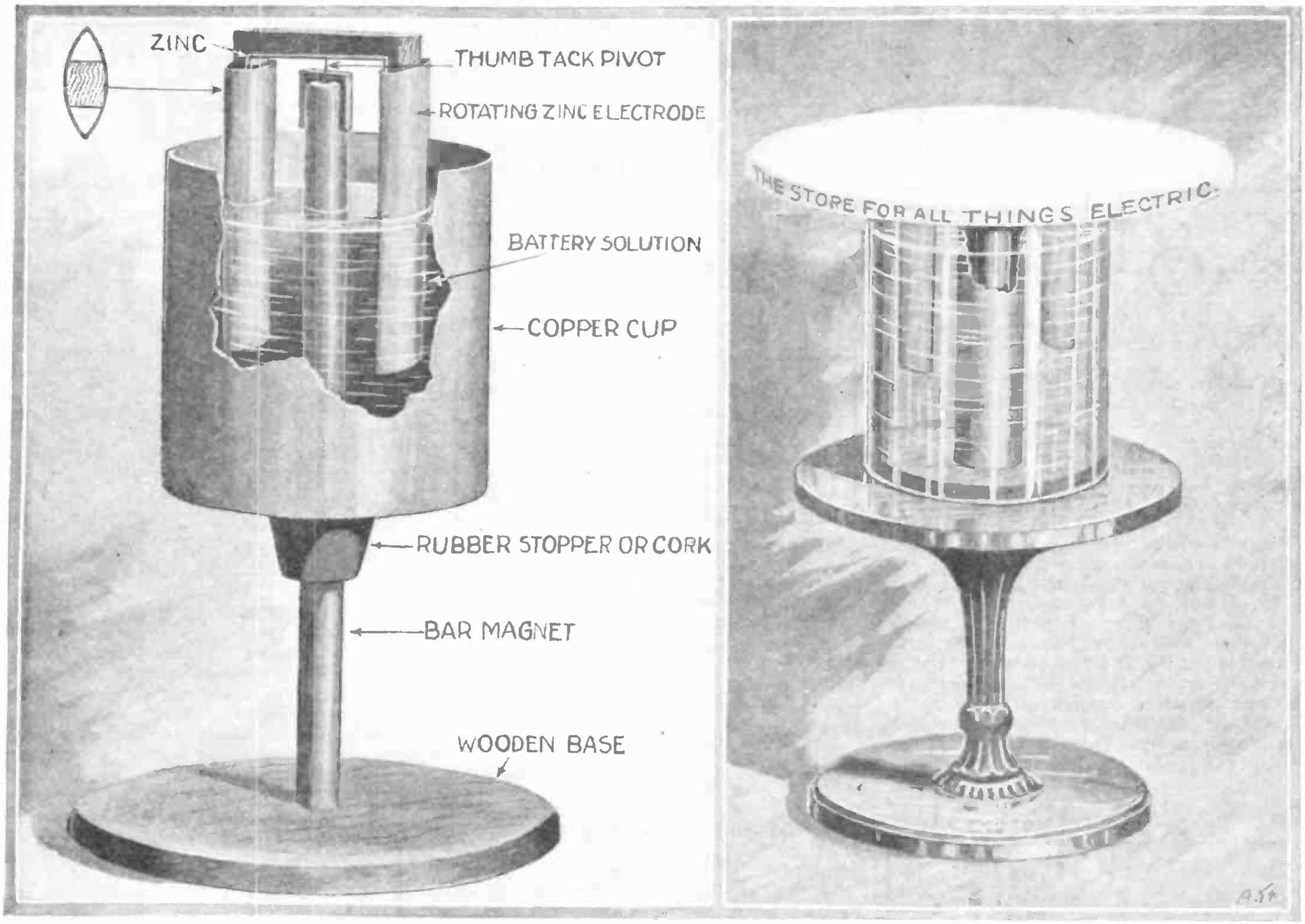
It is absolutely safe to handle this copper-coated phosphorus, even when dry, with the hands. Instead of being kept under water, the phosphorus may be kept in the copper sulphate solution.

Contributed by ELMER J. GARBELLA.



Motor Generates Its Own Power

By Earle R. Caley B.Sc.



This apparatus, consisting of a rotating element in a copper cup, seems at first glance to be the long-sought perpetual motion machine. On examination, however, it is found to be a voltaic cell, whose elements are constituted by the copper cup and a zinc electrode mounted on the rotating element. The latter revolves around a central permanent magnet by virtue of the reaction between the field of that magnet and the field set up by the electric current. A modified form of the apparatus designed for window display is shown at the right.

A UNIQUE electric motor that contains within itself the battery necessary for operation is shown in the illustration.

The battery cup in this motor is mounted about the middle part of the bar magnet. This cup is made of copper and besides containing the battery solution also acts as one electrode of the motor cell. It is in electrical contact with the magnet. The zinc electrode is formed of sheet zinc on a light wood frame and is arranged to revolve upon a point at the top of the bar magnet.

In operation the cup is filled with dilute acid and the current flows up from the copper through the magnet and along a strip of zinc to the vertical arms. In flowing down the arms of the zinc electrode, it forms a magnetic field that causes the rotation of the zinc electrode around the magnet.

The bar magnet used should be a fairly strong one about eight inches in length and preferably circular in cross section. Such magnets can be procured at electrical or scientific supply houses. This magnet is then mounted in a suitable hole drilled in a base of one inch wood that measures six inches on a side. The battery cup is made from stiff sheet copper and should measure three and a half inches in diameter with a height of four inches.

In the exact center of the bottom of this cup a hole is punched or drilled. This hole should be made a trifle smaller than the diameter of the magnet so that it fits tightly. A rubber stopper or a cork is next taken and a large hole cut in this so that it also tightly fits the bar magnet. This support for the copper cup is then placed half way down the bar magnet. The paint that usually covers such magnets is then scraped or sandpapered off above this support in order to ensure good electrical contact for the copper cup. The cup is slid into its place, resting upon the top of the cork or rubber stopper. The cup is now rendered leak proof by pouring in a layer of paraffin wax about one-eighth of an inch deep on the bottom. Paraffin wax is also painted over the part of the magnet lying within the cup.

The pivot upon which the rotating zinc electrode revolves is an ordinary inverted thumb tack.

The U-shaped zinc electrode measures four inches in length and two and a half inches across the bend on the outside. The cross section of the zinc is shown in the picture. This electrode may be readily made of sheet zinc formed by casting thin plates in a sand or wood mould by using molten zinc obtained by melting up several ordinary battery electrodes in a sand crucible. A Bunsen burner forms a satisfactory source of heat for this purpose. It is very essential that the two arms of the electrode be of an even length and uniform thickness so that the zinc balances. After the rotating element is formed, a depression is punched on the under side of the cross piece and the electrode mounted in place. The zinc should revolve evenly with no trace of a rocking motion.

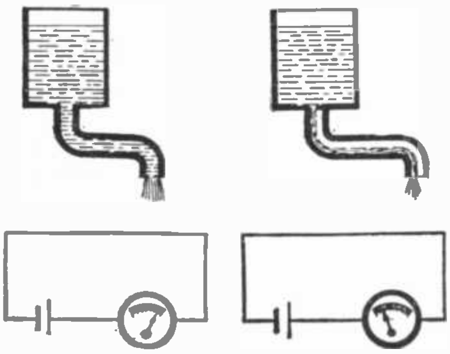
To start the motor in operation the cup is filled about three-fourths full of a 10 per cent. solution of sulphuric acid. Almost at once the zinc electrode will commence rotating around the magnet. By the motion of the electrode in this motor cell rapid polarization is prevented.

Internal Resistance of Cells

By F. S. Yamamoto

WHEN cells are used to furnish electrical current, the internal resistance of the cells must be considered in determining either the initial current or the current which the cells will produce when they are connected to some external circuit.

The initial current of a cell is the current obtained by connecting the cell directly



Figs. 1 and 2. Analogies between water tanks and electric cells, illustrating the initial curve of high and low resistance cells.

to an ammeter. This connection practically short-circuits the cell, as the resistance of the circuit is mainly the internal resistance of the cell itself. The ressitance of the ammeter is so low that it is not taken into consideration.

The reading obtained is the total current a cell will deliver on a short circuit. This method is often used in testing dry cells and is known as the short circuit test.

The diagram, Figs. 1 and 2, shows two tanks of water and two cells. The tanks have discharge pipes of negligible resistance. The internal resistance of the tank is represented by a large opening through which the water passes. It is evident that the flow of water through the large opening will be high and through the other case low comparatively. This corresponds to the

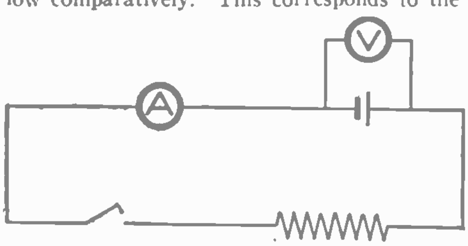


Fig. 3. Determining the internal resistance of a battery, using a resistance coil, voltmeter and ammeter.

initial current of the cells of low and high internal resistances.

For ordinary work, however, either of these tanks would give equally good service if the flow required were less than the initial flow of the high resistance tank. The same is true of dry cells. The required current in any kind of work is usually less than the lowest initial current; hence a low-current cell may give just as good results as a high-current cell.

The general rule to remember, in order to obtain the largest current flow from a cell or battery and thus the possible results, is: Connect the cells so that the internal resistance of the battery is equal to or approximately the same as the external resistance.

The internal resistance of a dry cell should also be taken into consideration, as the cell forms part of the complete circuit. A very simple method for the determination of the internal resistance of a dry cell is by Ohm's law:

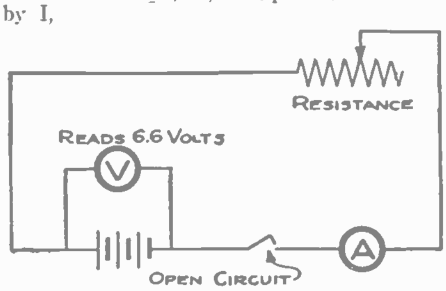
$$R = \frac{E}{I}$$

If we have a dry cell producing 1.5 volts on open-circuit and an initial current of 20 amperes its internal resistance can be calculated by the direct application of Ohm's law.

In this case $E = 1.5$.

$I = 20$ amperes.

The resistance, R, is equal to E divided by I,



The same experiment as before, but this time using a rheostat so as to follow up the voltage.

$$\frac{1.5}{20} = .07 \text{ ohm.}$$

This formally discussed way of determining the resistance is rather crude and in some cases not applicable, as in the case of a storage battery. If we would connect an ammeter directly across a storage battery in order to determine the total current which the battery would deliver on short-circuit, we would obtain the current reading of several hundred amperes, which might injure the ammeter as well as the battery.

In such cases we must connect the battery to some external resistance, for instance, a rheostat, so that the battery will deliver only a small current, about one to five amperes. The connection is illustrated in diagram, Fig. 3.

In order to determine the internal resistance, we must first take the voltage reading of a cell or battery before the external circuit is closed. This will give us the open-circuit voltage, which is called E total. On closing the circuit, the voltage reading across the terminals of the cell or battery will drop in proportion to the amount of current taken from the battery. This closed-circuit voltage reading is determined as well as the current reading from the ammeter.

The internal resistance is calculated from the following formula:

$$r_1 = \frac{E - e}{I}$$

r_1 represents the internal resistance of cell or battery; E the total voltage of the battery when the external circuit is open; e he voltage when the circuit is closed and I the current.

Now let us find the internal resistance of

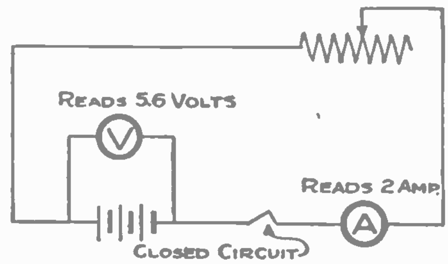


Fig. 5. The same experiment showing a reduced voltage on taking current from the battery.

the storage battery, whose total voltage (E) on open-circuit is 6.6 volts; the voltage on closing the circuit (e) 5.6 volts and the current 2 amperes.

The measurements are illustrated in Figs. 4 and 5.

From this data we may determine the internal resistance, thus:

$$r_1 = \frac{E - e}{I}$$

$$= \frac{6.6 - 5.6}{2} = \frac{1}{2} = 0.5 \text{ ohm.}$$

It makes no difference what current is drawn from the battery in determining its internal resistance. Let us assume that we take the same storage battery and change the external resistance so that three amperes will flow through the circuit. The condition will then be as illustrated in Fig. 6.

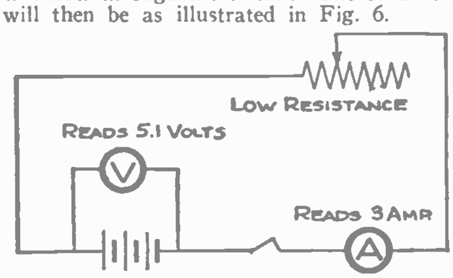


Fig. 6. Increased current is taken from the battery and the voltage falls still more as shown.

The internal resistance of the battery is the same, as is shown by the following calculation:

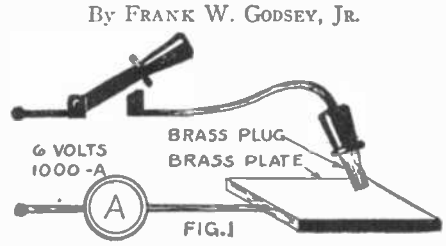
$$r_1 = \frac{E - e}{I}$$

$$= \frac{6.6 - 5.1}{3} = \frac{1.5}{3} = 0.5 \text{ ohm.}$$

Electric Spot Welding

By Frank W. Godsey, Jr.

ELECTRIC arc welding is associated with relatively high voltages and a flaming arc. Electric welding by true incandescence is done at a pressure of six volts or less and without any of the display characteristic of arc welding. When work is done by the incandescent method only sufficient pressure is used to ensure the passage of an adequately heavy current through the pieces of material to be welded. Fig. 1 shows the general characteristics of an apparatus for carrying out the process.



Simple arrangement for spot welding. A brass plate forms one electrode and a hand terminal forms the other.

The work is usually done on a plate of brass, the size of which is determined by the nature of the work. The plate is connected to one lead from the generator and constitutes a terminal. The other lead goes to a brass plug two or three inches long and tapering down to an end about one-quarter inch in diameter with tape wrapped around the upper part to hold it by. An ammeter is inserted in the circuit.

The great disadvantage of such a type

(*Continued on page* 476)

Electric Property of Plants

By G. Kainz

THERE is very little in the literature of the day about the exciting of electricity in plants, but such excitation is perfectly possible, as the following experiments show.

A leaf of common kohlrabi (*Brassica gongyloides*) was connected by a wire with an electroscope, keeping the leaf insulated from the table. I sprinkled it with water from an atomizer. The bits of gold leaf of the electroscope instantly separated, showing a negative charge, and the charge soon mounted up to a potential of 700 to 800 volts.

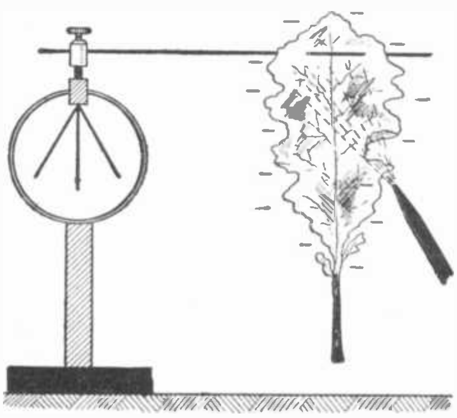
This excited my interest and induced me to carry the experiment further. I tried a whole series of plants to see which would show this electrostatic peculiarity. It was found that leaves of rape (*Brassica napus*), Mayflowers (*Convallaria majalis*), leek (*Allium ursinum*), cabbage (*Chelidonium majus*) and others showed negative excitation when sprinkled with common water.

I went on at greater length with these investigations, taking in about 200 other plant and tree leaves (*Phanerogams*) from which I got clear signs of electrostatic excitation. These samples were also subjected to impact of or sprinkling with finely divided water. The following showed negative polarity: Silver fir, large yew tree, pine tree, oak, laburnum, sumach, (*Rhus cotinus* and *Rhus typhina*) and several others. Linden, white and red beech, maple, poplar, willows and fruit trees showed no electrostatic excitation.

In order to avoid giving the names of every single plant that was investigated, it is necessary for the sake of brevity to put all the plants into groups or families to elucidate this electrostatic feature, as grasses, cereals (the *Cyperaceae*) and various kinds of clover, cultivated and wild, kohlrabi, rape, peas and vetch.

Naturally, of course, various kinds of mechanical, physical and chemical excitation could bring about electric charges, but in these cases the charge was apparently brought about by mechanical operation of the water on the face of the leaf.

The epidermis of the leaf consists on its outer layer or cuticle of the coating or cuti-



Water sprinkled upon a tree leaf by an atomizer electrifies the latter. The sign of the charge is negative with all species of leaves tried. To detect a charge the electroscope is first charged positively. This apparatus the gold leaf strips as indicated. Then when it is connected to the leaf, if the strips fall together the tree-leaf is negatively charged.

cle, then of an intermediate layer of cell-less material and then of the lumen of the epidermis cells. The cuticle and the intermediate layer beneath it are impregnated with wax in many plants. Its presence cannot be recognized by the eye, but is proved by the fact that on heating a section in water the melting wax comes out in the form of drops. The wax can be looked upon as the separating material of the epidermis cells whose membranes come close to each other. It generally appears in the form of little grains with which the cuticle is charged.

The delicate bluish glint which can be rubbed off with the finger, and which is seen upon the leaves and stalks of grasses and other plants can be seen in especially impressive forms on plums and other fruit. Sometimes the little grains form little rods on the surface of the epidermis.

The second appearance of the wax shows itself in a thin, transparent crust which forms an unbroken layer over the cuticle. In some cases this may attain a considerable thickness.

The wax impregnating the membrane of the cuticle, as well as any layer on the surface, prevents the reception of water by the leaf, and prevents the surface even being moistened as the drops roll off it. If such a leaf with its wax coating, which might be a leaf of the rape plant is dipped into water, it appears coated with a shining thin envelope of air and is not moistened. If the wax coating is examined with a magnifying glass, fine striations or grooves are shown, and one understands the mechanical progress of the excitation.

If a drop of water from the atomizer falls upon the grooved wax coating of the leaf, friction occurs between the coating of the water, which brings about an electric charge in the water and in the leaf. The coating on the leaf becomes negatively electrified and the water becomes positively electrified. The proof of this is that only the portion of the coating which comes in contact with the water shows the electric charge, as can be seen in the following experiment. If one removes from the surface of the leaf, which on sprinkling with water has shown strong negative excitation, the wax coating, by rubbing it off, and repeats the experiment on the same leaf, either none or a very weak charge of the leaf is shown.

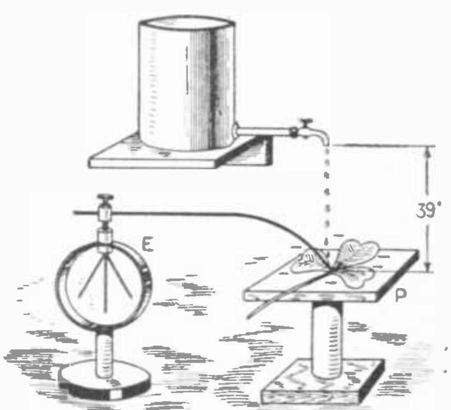
One can formulate the law that all plants whose leaf and stem are coated with a bluish white, glossy layer are negatively electrified by sprinkling with water.

In many grasses and grains the presence of silica on the surface of the leaves is the cause of electric excitation. In clovers oxalic acid, which is present in the outer layers of the leaves, causes electrification. The thing to be most noted in this is, that we find no plant which can be positively electrified by sprinkling with water. Water has, among all substances hitherto investigated, the highest electric constant, also called inductive capacity, namely 80. It must, therefore, electrify all things negatively which have a lower dielectric constant than itself.

What effect now have rain drops falling upon such plants? This question can again be referred to experiment. From a vessel at an altitude of about 39 inches or a meter, drops are allowed to fall upon a leaf of clover carried on an insulating stand (a block of paraffin (P) of the illustration). Wire connects the leaf to an electroscope. In a very short space of time after dripping begins, say 30 to 40 seconds, the electrometer (E) shows a tension of 400 to 500 volts for a fall of an exact meter, and at the rate of fall previous to hitting the leaf of 4.4 meters per second. If one substitutes for this terminal velocity nearly double the amount for rain drops, say 8 meters per second, we will be led to believe that a very great quantity of electric excitation may be due to rain.

We now come to this question: Can the electric content of the earth be explained by falling rain drops? There is no doubt that this can be answered affirmatively. If we picture to ourselves that the whole world of sweet and sour grasses, sugar cane and bamboo growth in the tropics, clover and the earth itself receive a negative charge from rain, we can readily understand that the earth has its charge of negative electricity increased thereby, and this has at last been proved by measurement and observation.

There is a further remark to be made. By fall of rain drops on the surface of leaves, the leaf, plant and earth are negatively charged. As this gives the rain drops positive charge, these drops falling on the earth must be exactly equal and opposite in



By the arrangement shown, the charging action of water or rain drops is illustrated. Water dripping from the faucet falls on a leaf and causes the latter to become electrically charged.

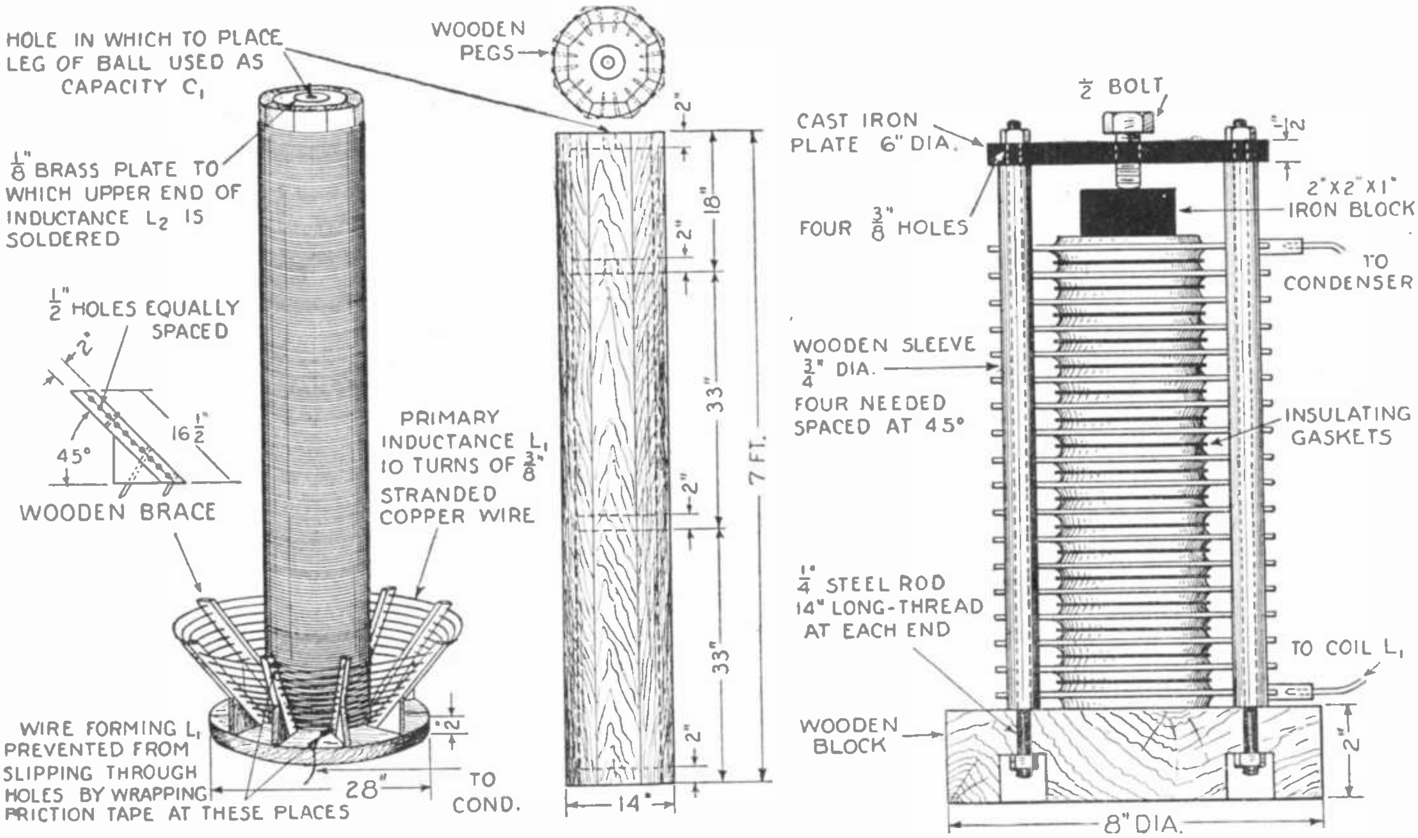
excitation to the electricity generated on the plant. But this is not really so, for by the impact of the rain drops on the leaves they are sprinkled about and give a part of their positive charge to the air, and this always

(*Continued on page 490*)

High Voltage Experiments

By Lester Reukema

(*Continued from March issue, page 342*)



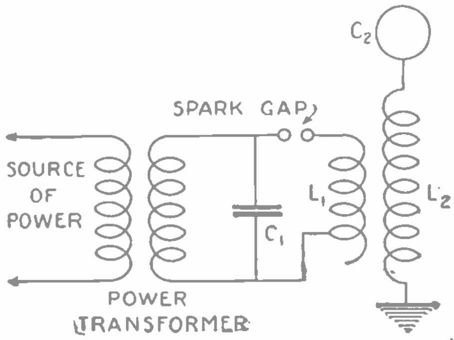
The illustrations at the left show details of a seven-foot high-frequency coil used at the University of California. The coil is extremely simple and can be constructed at very little cost by any amateur experimenter. At right is shown a very simple adjustable quenched spark gap. Illustrations reproduced from March issue.

THE entire outfit cost about fifteen dollars. Our power transformer is a 5-k.w. distribution transformer, with a ratio of transformation of 110 or 220 to 30,000 volts. We often work it up to 50,000 volts and 40 kilowatts for a few minutes at a time without serious overheating.

The source of power can be merely the ordinary 110-volt 60-cycle lighting circuit, although a 220-volt source will produce a more powerful display. In the diagram is presented the power transformer, which steps-up the voltage from 110 or 220 volts to 30,000 volts. Wires connect the high-voltage terminals of this transformer to the condenser (C_1). From the condenser one wire goes to the spark-gap (S.G.) and the other to the coil of wire (L_1), the connection merely clipping on to the coil, so that the number of turns of coil used can be readily changed. The other end of the coil is connected to the spark-gap, as shown. The coil (L_1) is merely a few turns of heavy wire, wound in the form of the lower half of an inverted cone. Fig. 14 is included merely because it shows how this coil is made, and how the large coil (L_2) is placed with respect to it. The large coil is seven feet long, 14 inches in diameter, and contains 750 turns of No. 22 copper wire, double-cotton covered. However, these dimensions are not essential.

Another coil, six feet long, a foot in diameter, with 1,000 turns, gave equally good results. The important thing to remember is to use no nails or other metal in its construction, as eddy currents set up in such metal by the high frequency power would soon set fire to the wood. The lower end of the winding on the large coil is connected to ground. A water pipe serves this purpose nicely. *Do not use a gas pipe, as sparks may ignite the gas,* if any is leaking out into the air. The upper end of the coil is connected to whatever is used as the secondary capacity (C_2), a man in a sink full of water in this case, or a ball or various other terminals. The coils (L_1) and (L_2) together serve as a loosely coupled air-core transformer. The condenser (C_1) consists merely of several pans of milk bottles filled half full of salt water, with salt water to the same height outside the bottles.

In a condenser, all that is necessary is two conducting elements separated by some non-conductor. In this case the salt water inside and outside the bottles forms the conducting surfaces, separated by the glass as the non-conductor. One high-voltage terminal of the power transformer is connected to the water outside of the bottles, the other to the water inside. To make this latter connection, we connected the transformer terminal to a piece of window screen placed on top of the bottles, then dropped short wires from the screen into the water in the bottles. In order to cut down corona loss in the condenser, a little oil was poured on top of the water. This, however, is not essential. The spark-gap used at first was a rotary gap, but later a quenched gap was used in its place, and gave better satisfaction. This consists of several disks of brass about six inches in diameter and an eighth of an inch thick, piled on top of each other with insulating gaskets 1/32 inch thick separating them from each other. The inner diameter of the gaskets was made about an inch less than the outer diameter. The whole pile was pressed firmly together to make the short gaps between disks air-tight.



The diagram illustrates the connection of the Tesla coil to a power transformer. A condenser C1 is constructed of a large number of milk bottles containing salt water, themselves immersed in a large pan of salt solution.

The spark-gap is made just long enough to require the maximum value of voltage to discharge across it. As the spark passes the gap the air is ionized and thus made conducting, so that the resistance of the gap is decreased to an ohm or less, and the energy stored in the condenser surges across it. The discharge of a condenser, unless the resistance of the circuit is too great, is oscillatory, that is, the current surges back and forth until the resistance gradually uses up all of the energy. And just as a pendulum swings at a certain frequency, determined by the length of the pendulum, so the frequency of the surges to and from the condenser is determined by the capacity of the condenser and by the inductance of the circuit. The equation for the frequency of the oscillations is $f_1 = \frac{1}{2 \times 3.1416 \sqrt{L_1 C_1}}$, where f_1 is frequency in cycles per second, L_1 is inductance in henrys of coil L_1, and C_1 is the capacity in farads of the condenser (C_1).

Now, as the surges of current pass back and forth through the coil (L_1), a magnetic field is set up which links with the large coil (L_2) and induces a current in it. If the

(*Continued on page 490*)

Electro-Magnetic Induction

By Harold Jackson

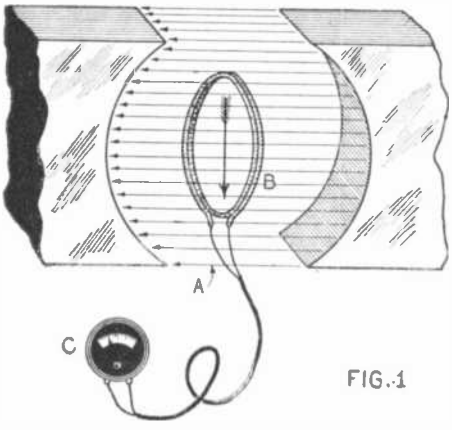


FIG. 1

Diagram explaining the potential induction. A coil of wire cuts a field of force without result.

ALL dynamos of whatever form are based upon the phenomenon discovered by Faraday known as "induction." This word has several meanings as applied to electricity. Its general meaning is the effect produced in bodies by the influence of other electrified bodies having no electrical connection between them.

If a body charged with electricity be placed near an uncharged body the charged body will "induce" charges in the uncharged body; this is known as electro-static induction. A magnet will induce magnetism in neighboring bodies of iron by the process called "magnetic induction."

The electric current induced in a conductor by moving it in a magnetic field so as to cut the magnetic lines of force is caused by the phenomenon of "Electro-Magnetic Induction." If the conductor is in the form of a coil, the movement of this coil must be such that the number of lines of force passing through it will be altered; for example, if the coil of wire is passed through a uniform magnetic field in a straight line as shown in Fig. 1, at (B) no current will be induced in it as indicated by the galvanometer (C), which is connected between the ends of the coil.

The reason for this is that the coil in a straight down movement leaves as many lines of force behind as it gains in movement. In other words, the number of lines of force embraced by the coil is not altered in its movement; such condition of change is necessary for the induction of electric currents in the coil. If the same coil be secured to a shaft provided with a crank as shown in Fig. 2, so that it can be rotated, as indicated by the arrow, the number of lines of force embraced by the coil will be altered and an electric current will be induced in the coil, which will be indicated by the deflection of the galvanometer needle.

In Fig. 2, starting with the coil in a perpendicular position, the first quarter of a revolution will raise the pressure in the coil from minimum to maximum pressure, the next quarter turn the pressure will die down to minimum again. The same process will occur in the remaining half revolution of the coil. Therefore there will be two electric impulses induced in the coil for every revolution it makes in the magnetic field. For one-half of the cycle the induced current in the coil will flow in one direction, and, in the opposite direction during the second half. Alternating current will be induced in the coil as it is revolved in the magnetic field, cutting the lines of force that thread from the north to the south pole of the field magnet.

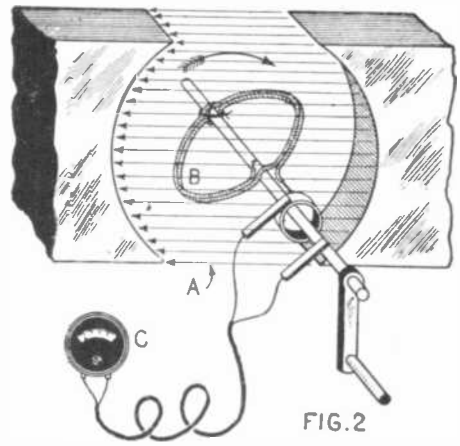


FIG. 2

Here lines of force are so cut that the number traversing the coil changes, thereby generating electric potential as shown on the voltmeter.

The rate of increase or decrease in the number of lines of force embraced by the coil governs the electro-motive force induced therein. The e.m.f. is increased with the increase in number of turns in the coil, also by the increase in speed at which the coil is rotated.

The direction of the induced current is always such that its magnetic field opposes the motion which produces it.

Voltmeter for Determining Capacity

IT is frequently desirable in radio and other electrical work to determine the capacity of a condenser. It may be one which has not been rated, or one on which the mark giving the rated capacity has been obliterated by wear.

Another valuable use in determining the capacity of a condenser is to find whether its capacity has decreased or not, due to internal causes. Condensers will deteriorate. as is well known, and if it is desirable occasionally to find whether they are up to normal capacity or not, the method outlined below will provide a convenient means for checking up. Care should be taken not to use too high a potential on a condenser not so rated. The figures used in these computations are simple enough for anyone having only elementary mathematical knowledge.

Hook up the circuit as shown in Fig. 1 and connect one terminal solidly to one side of the supply circuit as shown. Now touch the terminal (D) of the voltmeter to the point (A) and take the voltmeter reading. Next touch (D) to the contact (B) and take this voltmeter reading. In this case, of course, the voltmeter is in series with the capacity. Next note carefully the rated resistance of the voltmeter. These are all the readings that are necessary, and it is then a matter of a few computations to find the capacity of the condenser.

Suppose that the full voltage across the line was found to be 100 volts, and in series with the condenser, 40 volts.

Use this formula:

(1) $$E_O^2 = {}_rE^2 + {}_xE^2$$

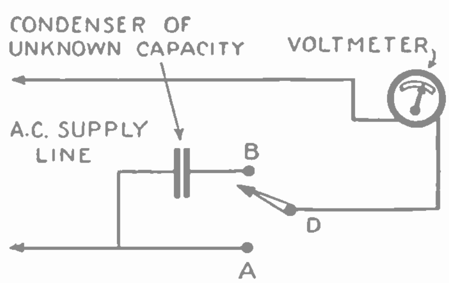


Diagram of the connections for testing the capacity of a condenser by means of a voltmeter and in the article the formulas are given for getting such data, so much in demand by the radio experimenters.

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>
> EDITOR.

Where $E_O = 100$ volts and ${}_rE = 40$ volts and ${}_xE$ (or reactive condensive voltage) is unknown.

Then $100^2 = 40^2 + {}_xE^2$ or

${}_xE^2 = 100^2 - 40^2 = 10{,}000 - 1{,}600 = 8400$

Therefore, ${}_xE = \sqrt{8400} = 91.6$

(2) $${}_xE = \frac{I}{2\pi \times f \times C}$$

Where I is the current flowing in the condenser, π is 3.1416, f is the frequency (generally 60 cycles) and C is the unknown capacity to be found in farads. I is conveniently found by dividing the series voltmeter reading,[1] by its own resistance. In this case suppose the voltmeter resistance is 10,000 ohms.

Then $$I = \frac{40}{10{,}000} = .004 \text{ ampers.}$$

The only unknown quantity is C and by transposing formula (2), we get its value:

$$C = \frac{I}{2\pi \times f \times {}_xE} = \frac{.004}{2 \times 3.1416 \times 60 \times 91.6}$$

$$= \frac{.004}{34{,}532} = .000000115\text{f.}$$

As this value is in farads and the capacities are generally rated in microfarads, multiplying this value of .000000115 by a million, or moving the decimal point to the right six places will give the correct capacity of the condenser in microfarads, in this case .115 mf.

Contributed by SAM J. SLOTZKY.

Electric Spot Welding

(Continued from page 472)

of welding outfit is that only certain metals may be welded with it, iron working about the best. It is mostly used to weld wires and then heating together in making electrical connections and wire fencing. The wires are laid across each other in the brass plate, the end of the plug is held tightly on the upper wire directly over the point or contact of the two wires, and the switch is closed for an instant. When the operation is done right, the wires become red hot, then white hot, and held together just as the switch is opened. If the plug is not held tightly on the weld or the switch is left closed too long, sparks and smoke out of molten iron are showered out from under the plug and the operation is ruined. It is *very* desirable to wear asbestos gloves in an operation of this sort, nor for protection from the current, but from the heat of welding the wires and the occasional slips which cause showers of sparks.

A generator suitable for this work must be capable of withstanding very sudden changes of load. One which stood up admirably under the demonstration of electric spot welding at the Rice Institute's last engineering show was a 6-volt G. E. generator with a Tirrill voltage regulator, capable of delivering 500 amperes, driven by a direct connected induction motor. The voltage regulator made possible the dropping of the voltage down to four volts and was capable of increasing it to seven. Using No. 12 iron wire to demonstrate with, four volts operated better than higher voltages and the amperage drawn was between 250 and 500 amperes.

There is very little danger of shock in working with such low voltages on direct current, yet a very severe burn may be received as contact is made on the body at points very close together. Therefore, care must be used in the work.

A very convenient application of the welding process just described may be of use to many experiementers in doing fine work, such as welding thermocouple joints.

A small block of wood or bakelite is secured, and two narrow strips of brass 1/16-inch thick and two or three inches long are screwed upon opposite sides of the block, as in Fig. 2. A binding post is fastened on each strip and two small cylinders of brass are brazed or riveted to the ends of the strips. A compression screw is passed through the two strips and a fibre bushing is placed between it and one of the strips. Very fine welding may now be done by laying the wires cross-wise between the ends of the two cylinders and tightening the compression screws, the binding posts being connected to a storage battery through a low resistance rheostat.

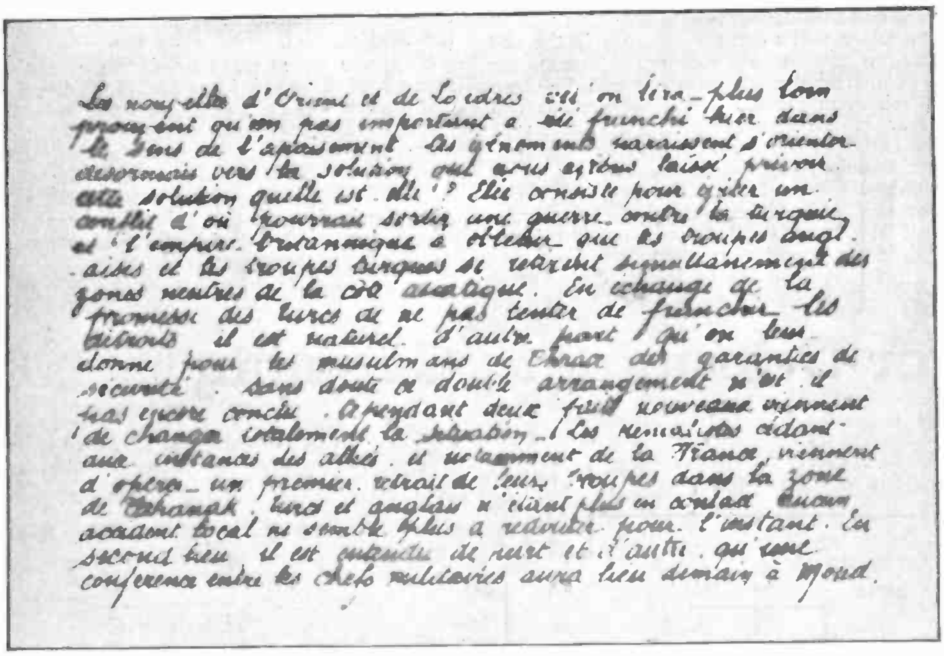
Several trials may be necessary before a good weld is secured, but once the little knack of judging the right time for the weld is learned, very fine work may be done easily and swiftly.

In soldering in close places in a radio set this little outfit is very handy. A little soldering paste is touched to the wires, the cylinders are compressed over them with the fingers and are drawn away while the solder is still molten to prevent its sticking to the brass.

A great strain is placed upon a battery in work of this kind, but by using a suitable rheostat and by the exercise of care a good one will stand up for a long time. The apparatus may also be worked from a step-down transformer. The secondary coil should be of copper ribbon to give a good cooling surface to avoid heating under such heavy loads.

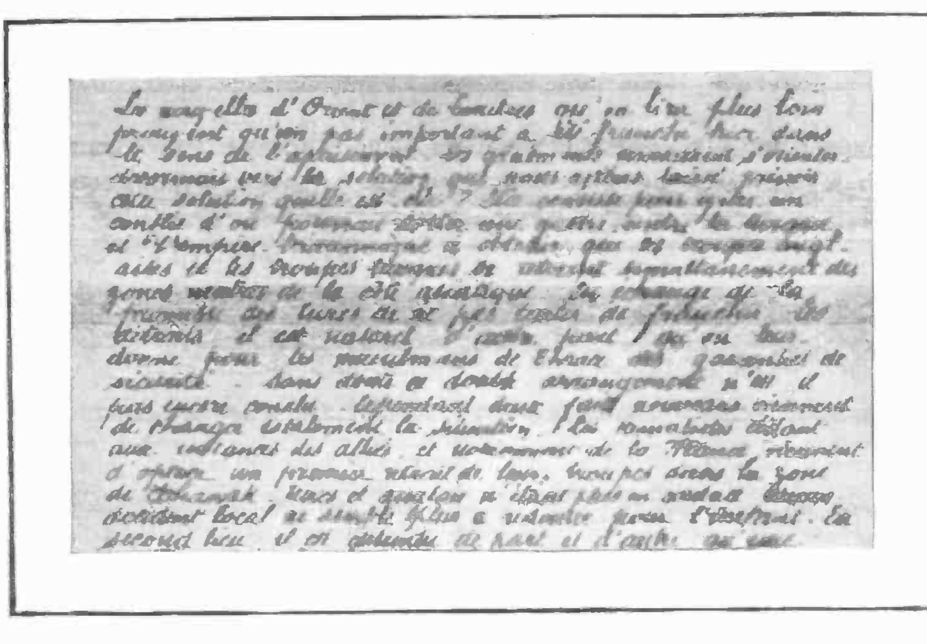
Transmission of Pictures, Printing, Autographs and Finger Prints by Wire and Radio

(Continued from page 452)



Les nouvelles d'Orient et de Londres où on lira plus loin prouvent qu'un pas important a été franchi hier dans le sens de l'apaisement. Les événements paraissent s'orienter désormais vers la solution que nous avions toujours laissé prévoir. Cette solution quelle est-elle? Elle consiste pour éviter un conflit d'où pourrait sortir une guerre entre la Turquie et l'empire britannique à obtenir que les troupes anglaises et les troupes turques se retirent simultanément des zones neutres de la côte asiatique. En échange de la promesse des Turcs de ne pas tenter de franchir les détroits il est naturel d'autre part qu'on leur donne pour les musulmans de Thrace des garanties de sécurité. Sans doute ce double arrangement n'est il pas encore conclu. Cependant deux faits nouveaux viennent de changer totalement la situation. Les Kemalistes cédant aux instances des alliés et notamment de la France viennent d'opérer un premier retrait de leurs troupes dans la zone de Tchanak. Turcs et anglais n'étant plus en contact aucun accident local ne semble plus à redouter pour l'instant. En second lieu il est entendu de part et d'autre qu'une conférence entre les chefs militaires aura lieu demain à Moud.

Two examples of transmission of writing are given here. One was transmitted by wire, the other by radio. They are absolutely autographic. Short-hand could have been used to get more into a given space. On pages 452 and 453 interesting examples of transmission are given such as Chinese letters, finger prints and a prisoner's letter.



Les nouvelles d'Orient et de Londres où on lira plus loin prouvent qu'un pas important a été franchi hier dans le sens de l'apaisement. Les événements paraissent s'orienter désormais vers la solution que nous avions toujours laissé prévoir. Cette solution quelle est-elle? Elle consiste pour éviter un conflit d'où pourrait sortir une guerre entre la Turquie et l'empire britannique à obtenir que les troupes anglaises et les troupes turques se retirent simultanément des zones neutres de la côte asiatique. En échange de la promesse des Turcs de ne pas tenter de franchir les détroits il est naturel d'autre part qu'on leur donne pour les musulmans de Thrace des garanties de sécurité. Sans doute ce double arrangement n'est il pas encore conclu. Cependant deux faits nouveaux viennent de changer totalement la situation. Les Kemalistes cédant aux instances des alliés et notamment de la France viennent d'opérer un premier retrait de leurs troupes dans la zone de Tchanak. Turcs et anglais n'étant plus en contact aucun accident local ne semble plus à redouter pour l'instant. En second lieu il est entendu de part et d'autre qu'une

by radio. Referring to the diagram which shows the controlling mechanism, it will be seen that three steps are required to establish synchronism:

These three steps are here given in detail. Reference must be made to the diagram on the opposite page. If the explanations are followed it will be clearly understood on what general principles the Belin apparatus is founded.

No. 1. To impart to the disc (B) driven by the motor, a convenient speed which can be regulated by a rheostat. The chronometer (C), to which the pendulum was previously adjusted, controls the armature of the electromagnet (E) by the action of the relay (R). The speed of the motor is regulated by means of its rheostat in such a way that the stoppage of the disc (B) is adjusted at each turn to a minimum interval. The switches (K) and (H) being shifted from the position 1 to position 2, every beat of the chronometer is heard in the telephone (T) connected to the system to the transformer (PS). On the other hand, at each turn of the disc (B) the circuit of battery (p_3) is closed through the primary (P), when the contact (L) of the disc (B) meets the contact (b_1) of the gear (A). Let the key (M) be in its normal position, that is, making contact at (c_2).

When the contact (L) of the disc (B) meets the contact (b_1) of the gear (A), a second tick is heard in the telephone (T); it is easy in adjusting the gear (A) by means

The picture above and the one on the right are reproductions of views transmitted by wire. It will be seen how wonderfully perfect they are, and they form a great testimonial to the Belin invention.

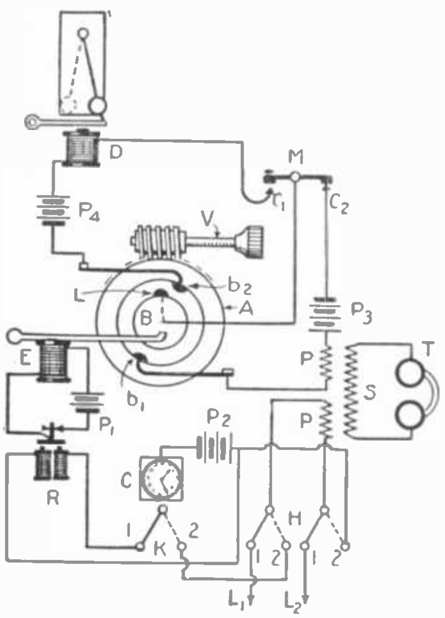
nitely known that the local tick is produced when the pendulum of the transmitter passes its vertical position.

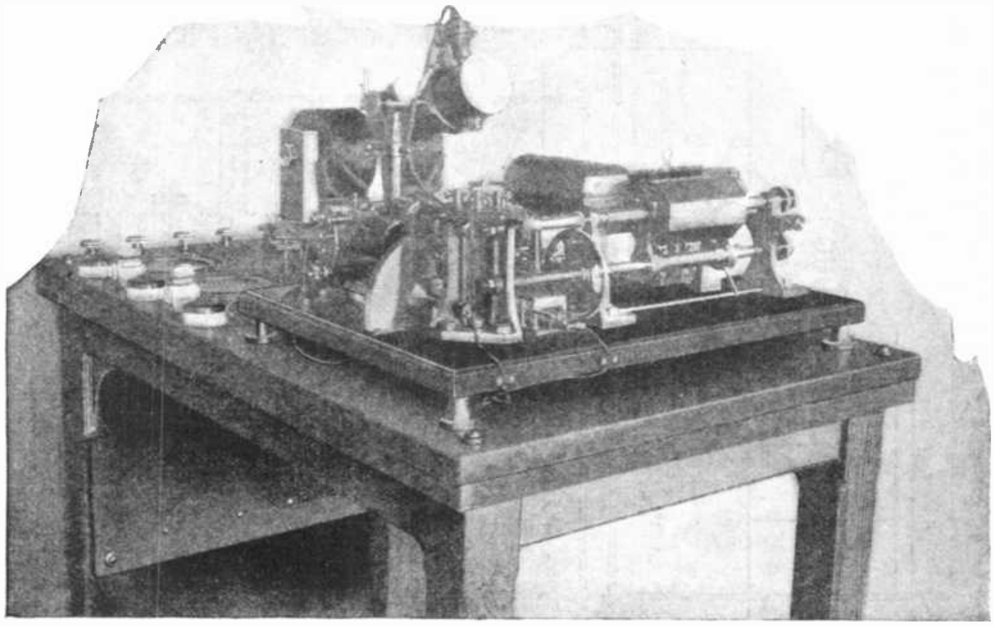
No. 3. If it is desired to release the pendulum of the receiver in exact coincidence with that of the transmitter, it is necessary that the electromagnet used to maintain it at its maximum oscillation should release it exactly a half oscillation after the tick coming from the transmitter. This will happen necessarily after a half revolution of the disc (B), for the latter is adjusted to make exactly one turn for each oscillation of the pendulum. The gear (A) carries for this purpose a second contact (b_2) diametrically opposite the contact (b_1).

The contact (b_2) is connected through battery (p_4) to the release-electromagnet of the pendulum and to the contact (c_1) of the key (M). Having established coincidence by the action of (b_1) and the proper adjustment of the gear (A), the operator presses the key (M) and thus secures the action of the contact (b_2).

When the disc (B) has made a half turn, the contact (L) meets (b_2), closes the circuit of battery (p_4) and the pendulum is automatically released exactly at the moment when the transmitting pendulum itself passes the central point.

Another field of development which may utilize this principle is in the transmission of photographs and moving pictures by radio or television. By dividing the picture into sections or dots in the ordinary halftone illustration and allotting to each dot a circuit tuned to a separate wave-length we can transmit each one of these wave-lengths over the high frequency beam and receive them at the receiver composed of the same number of circuits, each one of which produces an effect on a screen that will give us the entire picture. Future developments in photoelectric cells will no doubt make this possible. The thing most to be desired is a light-sensitive conductor without lag. There is little hope of a transparent one.





This shows the hook-up or circuits of the Belin apparatus; the pendulum will be noted in the upper left hand of the diagram, and on the right the ear-set, because the synchronism is established by listening for definite ticks. The synchronism, if exact, is only so by accident, because the principle is that two rotating drums at distant points, one sending and one receiving, are justified once in each revolution; so that each revolution starts correctly though it will inevitably end a little out of synchronism. A view is also given of the Belin apparatus.

of the worm (B) to make these two ticks coincide and to verify in this way the isochronism of the disc (B) with the chronometer (C).

No. 2. On changing the switch (H) from position 2 to position 1, the chronometer no longer acts on the telephone and the latter produces only the ticks coming from the transmitter.

By the adjustment of the gear (A) the two series of ticks coming respectively from the transmitter and receiver are set in coincidence, and when this is done, it is defi-

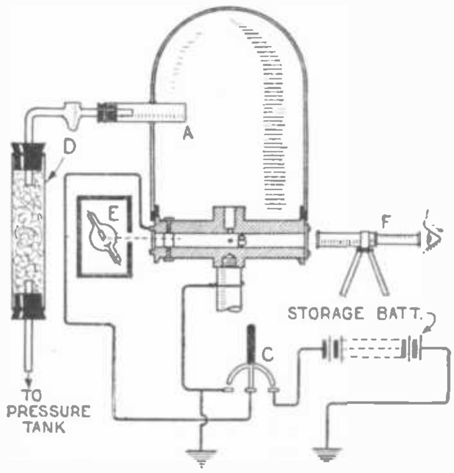
The Charge of the Electron

(*Continued from page* 454)

What is the charge on the electron? It is difficult to conceive this quantity on account of its extreme minuteness. Speaking in the language of the scientists the charge carried by each electron is 1.59×10^{-20} electromagnetic units of charge. This means in simpler language that when a current of one ampere passes through a wire 6,290,000,000,000,000,000 electrons must pass a point in that wire every second.

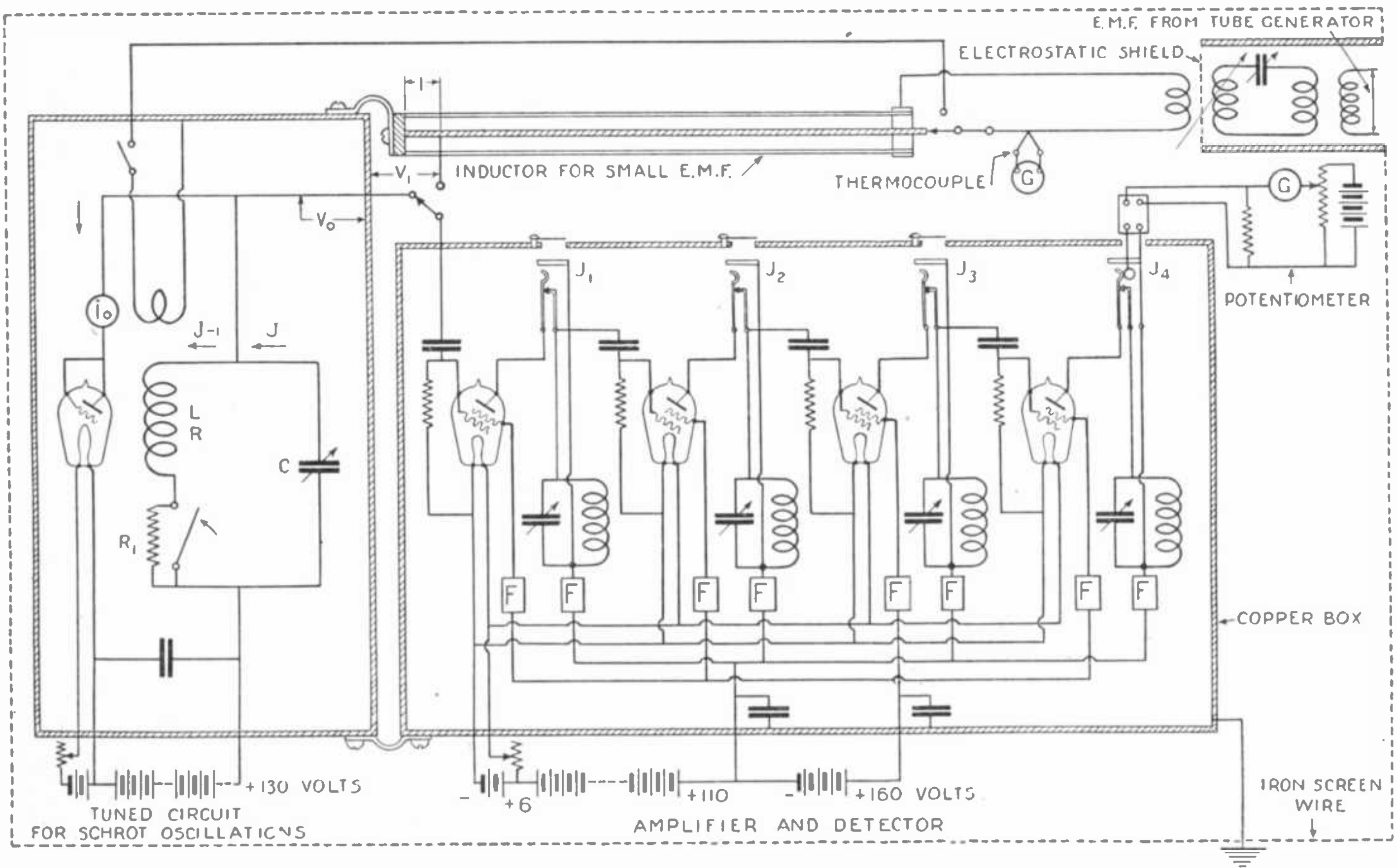
Doctors Hull and Williams took it upon themselves to do what amounts to counting the number of electrons passing per second from plate to filament of a vacuum tube and by determining the total charge carried from the plate to the filament, to compute the charge carried by each individual electron. This process was rendered possible by the purely mathematical investigations of Professor W. Schottky.

Before he discovered this method a prominent American scientist, Professor Millikan, had measured the charge on the electron by isolating an individual electron and studying its behavior under the influence of the electric field. In Fig. 1, (A) is the Millikan apparatus used for this purpose.



Professor Millikan's apparatus includes an atomizer, immediately above letter D in the illustration, through which air, purified by passage through glass wool in a tube, D, is blown. A cloud of extremely fine globules of oil with which the atomizer is fed are thus produced. Sooner or later a single one falls through the minute aperture at A and by electrifying the two plates one way or the other, is kept stationary or moved up or down. Additional charges are given to it by acting on the air between the plates with the X-ray tube, E, or with radium. The movements of the drop are watched through a telescope, F. The large storage battery gives a high and easily regulated potential of 10,000 volts to the plate; and the switch, C, connects the battery.

Oil is atomized into the glass dome at the top of the apparatus. This forms drops about one ten-thousandth of an inch in diameter, which fall at the rate of one-half inch per minute. The friction incident to the atomizing charges each drop with electricity. As the drops fall, a single one eventually finds its way through the very small aperture in the upper one of the two plates immediately under the dome. Although so small as to be invisible, it can be seen and its motions can be watched by a super-microscopic effect by the diffraction of light, by means of a powerful telescope. An electric potential applied to the plates by attraction from the upper or repulsion



The diagram shows details of the circuits used in determining the charge on the electron. The thermocouple and inductor were used to measure the voltage impressed on the tuned circuit in measuring its resistance. The potentiometer provided with a galvanometer, was used to measure the output current of the amplifier. The equivalent resistance of the tuned circuit was measured by observing the ratio of impressed e.m.f.s, with and without the resistance R1, which gave the same plate current in the amplifier. The measurement of this resistance was one of the difficulties involved in this experiment.

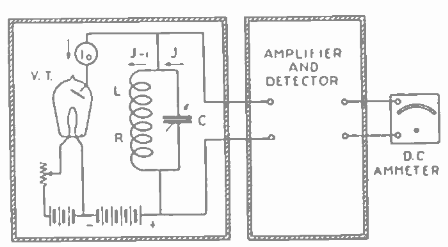
from the lower can hold the drop stationary or accelerate its rate of fall.

The charge on the droplet was changed by collision with ions, and these were produced by the action of radium on the air between the plates or the action of X-rays upon it. Omitting all details, it is obvious that the charge on the drop could be increased, neutralized or reversed as desired; by changing the charges on the plates all this can be effected.

The measure of the charge was the rate of most of the drops under identical conditions of the plates, and it was found that the changes were not graduated, but by steps as it were each edition being a multiple of the others, or rather of the basic ones, and is a demonstration of the phantom as far as the electric charge is concerned.

At the left in the figure is shown a working model illustrating the operation of the Millikan apparatus. The silk membrane suspended between two plates will move up or down depending on whether the plates are charged or uncharged. From the velocity of motion of the isolated charged drop, Professor Millikan computes by an ingenious method the charge carried by the electron which forms the center of the drop. For a more detailed but popular account of his method, the reader is referred to the January, 1918, issue of the ELECTRICAL EXPERIMENTER or Professor Millikan's book, "The Electron." By this method Professor Millikan arrived at the most accurate determination of the charge on the electron.

Dr. A. W. Hull and Dr. N. H. Williams devised a method for this determination which, while radically different from Millikan's method, yields results in very close agreement with the values obtained by Professor Millikan. This method consists in the measurement of the alternating current excited in the tuned circuit L, C, R, by the variations in thermionic current through the vacuum tube VT. Such variations are inevitable since the current consists not of a continuous flow, but of the interrupted emission of small charges, *i. e.*, electrons. This alternating current is amplified and rectified and finally measured by a D.C. ammeter. By means of an equation derived by Schottky



In measuring the charge on the electron, by the method developed by Drs. Hull and Williams, the problem was to measure the alternating current excited in the tuned circuit L, C, R by the spontaneous variations in the electron current through the vacuum tube VT. From the value of this current, the charge can be calculated.

the charge on the electron is then computed from the current and the constants of the circuit L, C, R.

This amplifier deserves special attention. It consists of four special pliotrons, constructed so as to be free of internal capacity feed-back, and, as seen in the figure, thoroughly screened externally. The system was completely non-regenerative and so the total amplification was the product of the amplifications of the individual amplifying tubes. The last tube being used for detection, the amplification was due to three tubes and amounted to 73,000. The experiments were carried out at a frequency of 750 kilocycles (a wave-length of 400 meters).

The method outlined here, while of importance in the measurement of the charge on the electron, has also important practical bearing on the study of vacuum tube characteristics. It gives an effective way of differentiating between the influence of temperature and space charge and between reflection and secondary emission of electrons in a vacuum tube.

The two methods are in wide contrast. It is interesting to see how Professor Millikan attacks the problem in the most direct possible way. Everything which he did was done without the use of any amplifying connections or apparatus, beyond the use of the principle of the ultra-microscope, which shows the presence of minute particles in the air which are only visible from diffraction; and this diffraction is utilized to acquaint the observer with their presence.

When a sunbeam passes through a room, it seems to be full of dust. If the dust is allowed to settle, and this can only be done by having the air confined in a practically sealed container, the beam cannot be traced through it. But the dust particles which make it visible in a strict sense are invisible themselves and only make their presence known by reflection and diffraction of light.

It is a wonderful achievement with such simple apparatus to produce a single drop one or two-twenty-five-thousandths of an inch in diameter, and to make that tell the story of the electron and of the elementary quantum of charge.

Measuring Radio Wave Lengths with a Meter Stick

(Continued from page 455)

of No. 12 B. & S. wire and in place of a condenser the tube capacity is employed. The loops are 7.3 inches in diameter, one loop being placed in the plate and one in the grid circuit. The arrangement illustrated in the photograph shows the tube between the two coils, giving a separation of 1.18 inch, and is a very convenient one. A diagrammatic representation of the circuit is shown in Fig. 3 where C and D represent the two loops, J a radio frequency by-pass condenser, which if made variable can be used to adjust the wave-length slightly. A

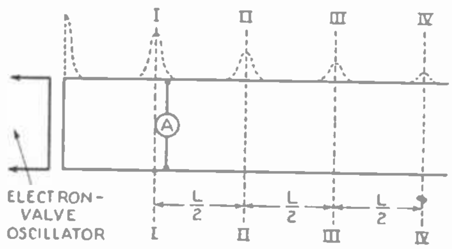


FIG. 1

The electron valve oscillator impresses very high frequency oscillations on the two parallel wires. The interaction of outgoing and deflected waves along these wires establishes points of maximum wave intensity, as indicated in the diagram. The moving thermo-galvanometer (A) indicates these points of maxima.

50-watt coated-filament tube is used. The internal capacity of this tube determines the upper limit of the frequencies obtainable with the circuit.

K are choke coils keeping radio frequency currents out of the battery and consist each of 13 turns of No. 20 copper wire wound on a wooden core one-half inch in diameter with a quarter inch between turns.

This oscillator produced a frequency of 33,000 kilocycles (nine meters); with a variable air condenser across the grid and the plate, the frequency could be considerably decreased and wave-lengths of 17 meters could be obtained.

In the Bureau of Standards experiment this oscillator was tuned to 30,000 kilocycles and its wave-length was exactly measured by the parallel wire system described above. Throughout the experiments the frequency of this oscillator was maintained constant. In Fig. 4 this fixed oscillator is represented by B. Another oscillator of variable frequency D was tuned to approximately 30,000 kilocycles and a short-wave receiver C was tuned to this frequency also. When the frequency of B and D are approximately equal, a beat note due to the interference of radiations from B and D will be heard in C.

Since the receiver C is tuned to 30,000 kilocycles, only the beat notes produced by the interference of waves of this frequency will be heard in it. If now the frequency of D is reduced, the beat note will be gradually eliminated, until by exact adjustment it is made to disappear entirely. If the frequency of D is further reduced, a point will be reached where a second beat note is heard in the receiver C. This beat note is due to the second harmonic of D, since when this beat note is heard, the interfering wave from D must have a frequency of 30,000 kilocycles and the fundamental frequency of D must be 15,000 kilocycles. The oscillator D can be further reduced in frequency until a third note is heard in the receiver C. The interfering radiation from D is now evidently due to its third harmonic and its fundamental must therefore be 10,000 kilocycles. This process can be continued to the lower limit of oscillations of D.

At each setting of the low radio frequency generator D, an accurate low-wave meter is tuned to D and calibrated.

Lower Radio Frequency Oscillator

The oscillator D used in the experiments described above has a range of 300 to 16,600 kilocycles and is illustrated in Fig. 5. As shown in the photograph, it is provided with three sets of interchangeable coils. The connections involve nothing unusual except three variable air condensers across the plate and grid of the tube. These condensers have capacities of .001, .0001 and .00005.

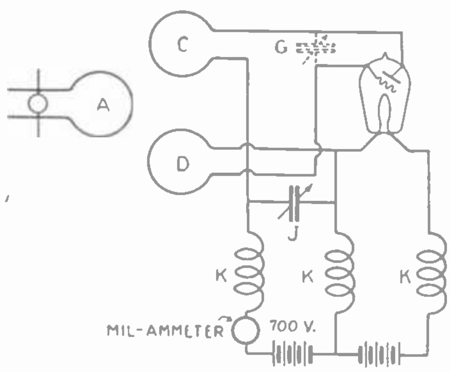


FIG. 3

A diagrammatic view of the oscillator used in Fig. 1 (A) is a loop which couples the parallel wires to the oscillator. The oscillator is designed to radiate waves of about five meters length.

The construction of the coils is clearly shown in the photograph.

Short-Wave Meter

The ultimate purpose of the experiments described is to accurately calibrate a meter for the measurement of short-waves. This meter as constructed by the Bureau of Standards consisted of a single turn of No. 5 B. & S. copper wire. The terminals were connected to the plates of a 50 mmf. varia-

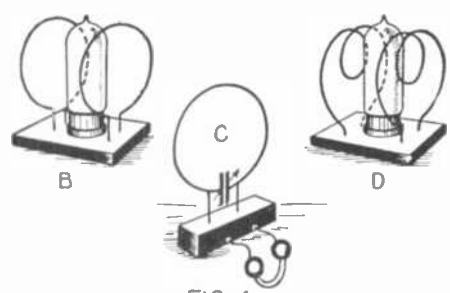


FIG 4

(B) is an ultra-radio-frequency oscillator tuned to 30,000 kilocycles. The receiver (C) is tuned in resonance with this frequency. The frequency of the oscillator (D) is varied, the interference between its radiations and those of (B) being heard in the receiver, whenever its fundamental or a harmonic is near 30,000 kilocycles.

ble air condenser of two plates. A thermo-galvanometer was placed in series with the loop. To increase the sharpness of resonance of the instrument, the thermogalvanometer was shunted with a piece of No. 14 B. & S. copper wire. To increase the range of the instrument, fixed air condensers of various capacities were shunted across the variable condenser. The photograph in Fig. 6 shows one of these fixed condensers beside the instrument. To eliminate capacity effects due to the approach of the operator's hand, the wavemeter was tuned by means of a long arm attached to the shaft of the condenser.

Short-Wave Receiver

The ultra-radio frequency receiver C (Fig. 4) consisted merely of a tuning element of a single turn of No. 12 B. & S. copper wire connected to a .00025 mfd. condenser. The terminals of this tuning element were connected to the input of a detector with two stages of audio frequency amplification. Throughout the measurements the receiver was located about five feet from either oscillator. The receiver is illustrated in Fig. 7.

Chemical Vegetation

(Continued from page 449)

world to produce some kind of life from inorganic substances.

Some of these experiments have met with a slight degree of success in that they were able to produce plant-like structures which increased but did not actually grow; which never had the spark of life, although they increased in size.

The membrane or cell wall, in living organisms, is a thin skin-like substance which, although closed, permits the passage of liquids in both directions. The contents of the cell consist of protoplasm, a thick, slimy substance which may completely fill the cell, or it may be found next to the cell-wall. It is this protoplasm which is responsible for cell growth as well as for the growth of the membrane. Protoplasm is of prime importance as all functions of the cell can be directly traced to the influence this substance has over its structures and protoplasm is the mysterious substance which is the carrier of life in an organism.

It is not difficult to produce such "plants," and no expensive chemicals are required. A seed of cupric chloride is dropped into a 3 or 4 per cent. solution of potassium ferrocyanide in water. The seed should be about half the size of a pea, and, in a short time, growth will begin. The first thing which appears is a tuberous root-like structure green in color which changes to a dark reddish brown. Soon little shoots are seen emerging from this tuberous structure which slowly increase in size. The root-like structure grows horizontally for a time if placed in a flat, tall dish; in a test tube it must, of course, grow upward. The shoots, on the other hand, grow upward from the horizontally growing tuber. These are thin and more or less flat and look like red seaweeds commonly seen cast up on the shores.

The cell-membrane, in this case, is very thin, especially when the seed has just been dropped into the fluid. Within this cell membrane, the remainder of the seed dissolves and forms a green solution. A few seconds later the seed, at first spherical, gradually elongates, increasing in height faster than it increases in width.

Why does the plant make its upward growth? In all probability because the membrane is thinnest at the extreme tip. And the reason that this is so is because the greatest concentration, within the cell, lies at the bottom of the cell and the weakest solution lies at the top, which is quite natural. Then, as water enters the seed by osmosis, the pressure within the seed increases beyond the limits of resistance of the weakest part of the membrane. It therefore breaks the membrane at this, the weakest

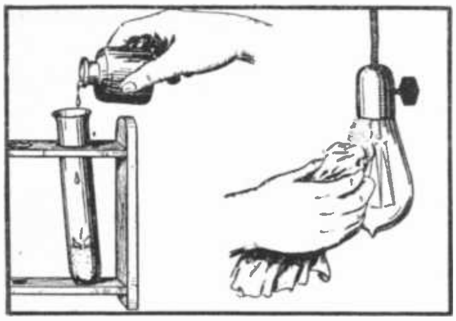
(Continued on page 492)

Frosting An Electric Bulb

By George E. Barbour

AN electric light bulb is often required which has a much more even distributing power than usual, and it is not always convenient to procure a special bulb. A bulb can be frosted as described below.

First clean the bulb to be treated. Then in a six-inch test tube put two teaspoonsful



A simple system for frosting an electric light bulb, using a strong solution of Epsom salts.

of Epsom salts and three drops of mucilage and add one teaspoonful of water. Heat to the boiling point so that everything will go into solution.

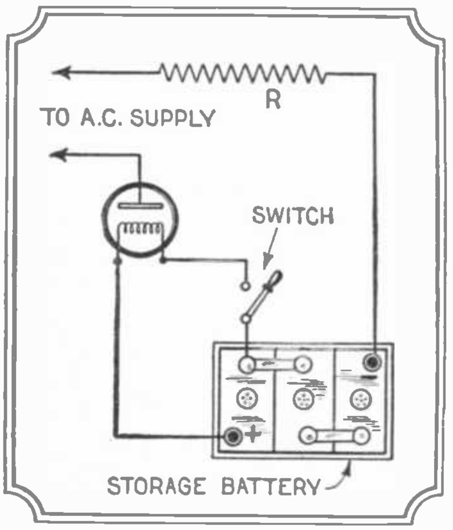
Apply the solution to the bulb while hot with a woolen cloth, using a medicine dropper if one is at hand. From one to three coats may be placed on the bulb. Allow each coat to dry for two or three minutes.

Tungar Rectifier

By Foster Fraas

TO the experimenter an inexpensive and easily constructed rectifier that requires little attention is always welcome. A rectifier working on the principle of electronic emission from a hot cathode answers his purposes very well.

The maintenance of the high temperature for the cathode usually necessitates a second source of current. In the Tungar tube the



A Tungar rectifier connected for charging a storage battery, so that once it gets started, a separate current for the filament is not needed.

cathode is in the form of a filament, which is heated by the passage of a current of about 10 amperes at a pressure of 2 volts. For this reason many experimenters reject this type of rectifier and rely either on an electrolytic or a magnetic rectifier.

The filament supply of the Tungar rectifier can be eliminated if the current between the cathode and anode is sufficiently large. In carrying out this system the resistance which the tube offers to the passage of the current transforms a portion of it into heat, keeping the cathode incandescent. To start the tube a filament current is needed, but only for a few seconds until the cathode is brought to the correct temperature. The current to be rectified should be of such a pressure that it will overcome the resistance of the tube.

At 110 volts the pressure is higher than needed, so a resistance must be inserted in the circuit. The diagram illustrates the manner in which a storage battery may be charged by this method. The resistance (R) should be of such a value as to allow a cur-

rent of 5 amperes to pass; since only one-half of the wave is rectified a current of about 2.5 amperes will pass through the tube.

The tube is a 2-ampere Tungar bulb, one of whose filament leads is connected to the positive pole of the battery, while the other is connected through the switch (S) to the negative pole of the same cell. The switch (S) is closed for a few seconds, until the tube begins to rectify and is then opened as quickly as possible.

In closing the switch (S) the current sometimes breaks in a bluish-white discharge across the electrodes of the tube before the filament has come to the correct temprature.

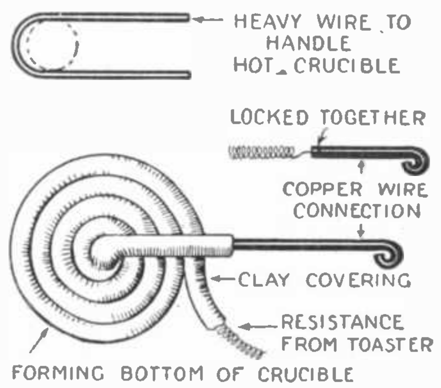
Making An Electric Crucible

By Roy Duncan

EXPERIMENTERS frequently require a small crucible for melting lead, zinc or combinations of both, as it is unpleasant and troublesome to melt them in the stove.

The writer has read with interest of various plans for making electric crucibles, but they required parts which were unavailable. Some broken resistance wire from an electric toaster, a large piece of asbestos 1/8-inch thick, and clay from a nearby vacant lot was at hand. Hardware stores can generally supply excellent fire clay.

The resistance wire was mended by straightening out an inch and a half of each broken end and twisting them together, after scraping them bright to get good contact. The two remaining ends were pushed through holes punched in the flattened ends of No. 14 copper wire 4 inches long, then squeezed with pliers to tighten the joint.



A very interesting system of constructing an electric crucible for melting metals. A heating coil embedded in clay is wound around and around helix fashion so as to make up a crucible.

This was to make it easier to connect to the lighting system.

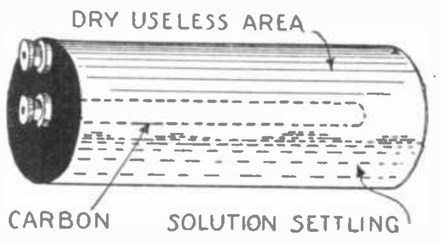
Beginning at an end of the spiral coiled resistance wire, coat it with fairly stiff clay so that the layer of clay will be 1/8 inch thick over the wire. This is then coiled like a clock spring (flat) to form the bottom of the crucible. The sides are then formed by putting one turn after another on top of the last instead of around.

A small lip is made on the top outer edge to direct the flow of the molten metal. The apparatus is allowed to dry for a week or two, and asbestos is then folded around the sides and bottom to a thickness of 1/2 inch or more, and bound on with fine, soft, iron wire, taking care that the iron wire does not touch the copper connections. Several squares of asbestos, one on the other, form a lid to hold in the heat.

With an inside measure of 1 1/2 inches in diameter, and 3 inches in depth, such a crucible will melt several pounds of metal at a time. It required fifteen minutes to melt two brass valve stems from old auto inner tubes.

Stand Batteries Up

DRY cells should never be laid in a horizontal position for any length of time,



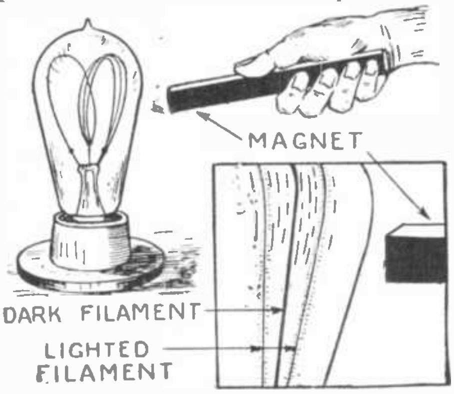
Suggestion for conserving and getting the good out of dry cells by keeping them in a vertical position.

as this will cause the solution contained in them to settle to the lower side, thereby weakening the battery and materially impairing its usefulness.

Contributed by Charles Dock.

Lamp Experiment

DOES a lamp lighted by alternating current glow during the periods of zero voltage? In other words, does the filament retain sufficient heat to bridge over these periods? The answer to this question, as



If the filament of an incandescent electric lamp supplied with alternating current is observed while vibrating under the influence of a magnet, a dark image of the filament will be noticed. This seemingly demonstrates that the filament cools below incandescence during each alternation.

determined by the following experiment, would seem to be that on commercial frequencies a lamp actually does "go out" 120 times a second.

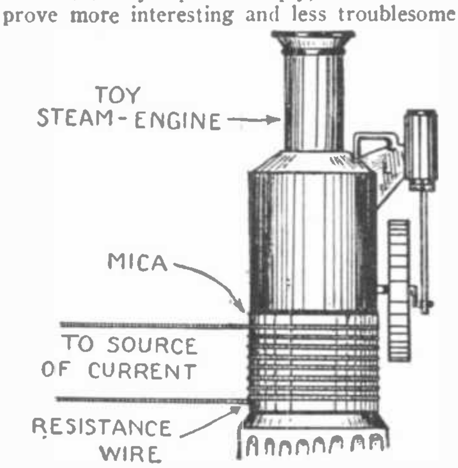
Hunt up an old carbon bulb and a horseshoe magnet, or if you prefer, an electromagnet. Be sure, however, to use a carbon lamp because its looped filament has more freedom of vibration than has a tungsten one. On bringing the magnet near the lighted lamp, you will find that the filament is set vibrating through a broad arc. This, of course, is "old stuff" to nearly everyone.

Now look closely at the broad band of light, and in its exact center you will find the black line of an unlighted filament. This shows that when the filament is at its midpoint of vibration—that is, when the alternating current has dropped to zero—the lamp is not emitting an appreciable amount of light. We do not notice any flickering effect because of the inertia of the eye.

Contributed by CHARLES D. SAVAGE.

Toy Steam Engine Heater

A TOY steam engine may be heated by electricity quite simply, which will prove more interesting and less troublesome



A toy steam engine whose boiler is usually supplied with heat from a spirit lamp is here provided with an electric heater. The latter consists merely of a few turns of resistance wire wound around the boiler from which they are insulated by a sheet of mica.

than when employing the ordinary method of using alcohol.

A piece of mica is wrapped around the boiler of the steam engine and around this are wound several turns of resistance wire, this being spaced so there will be no short circuits between turns. The amount of wire required will vary according to the voltage and size of the engine.

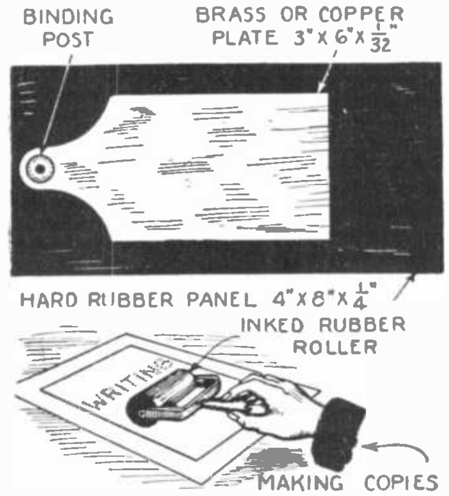
The wire may be left in this way, or, if desired, another layer of mica may be placed over it and over this a metal shield placed to protect the wire and prevent it from easily slipping out of place. This forms the heating unit of the engine and is connected to a battery or a small transformer. It is best to experiment with the amount of wire to use, so the proper temperature will be produced. *Contributed by* EVERMONT FISEL.

The Electric Pen

by ARTHUR A. BLUMENFELD.

THE preparation of stencils for the reproduction of writing and drawings has always been a matter of difficulty and never quite within the means of the amateur experimenter.

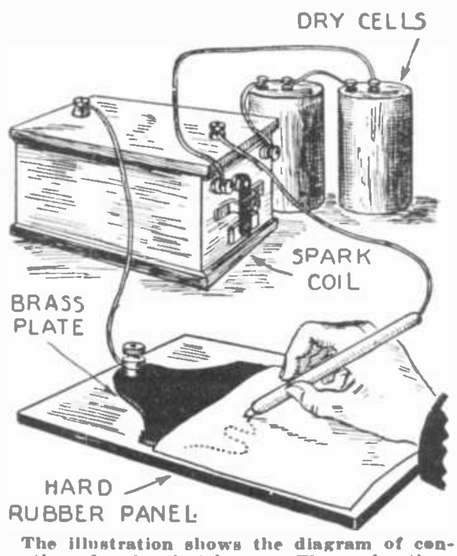
The method described here is one by which paper stencils can be readily prepared with



The upper illustration shows the base electrode for a novel stenciling process. A paper placed between this electrode and the metal pencil becomes perforated with fine holes as the latter is moved over it. The pencil and the plate are connected to the secondary of an induction coil.

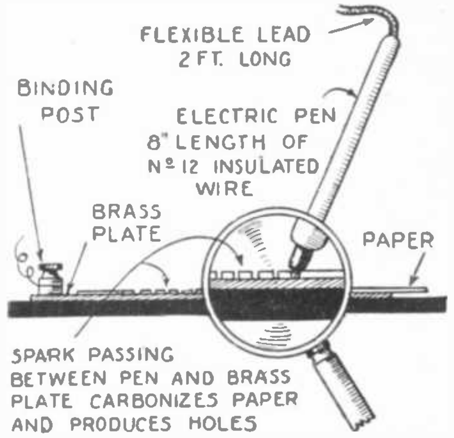
The lower illustration shows the method of reproduction from these stencils. The stencils can also be used in stereopticon projectors and for electric advertising signs.

the aid of no other apparatus than the ordinary induction coil with the customary auxiliary equipment. One secondary terminal of the induction coil is connected to a brass



The illustration shows the diagram of connections for the electric pen. The perforations are produced by small electric discharges between the metal pencil and the brass plate.

or copper plate while the other terminal goes to a dull metal point set in a pencil-shaped insulating rod. The paper is placed on the brass plate and, with the primary circuit closed, the operator proceeds to write or draw upon the paper. As the point moves over the paper minute sparks jump between it and the brass plate, puncturing the paper and forming writing or other design consisting of perforations following the lines described. The perforations can be varied in



This enlarged view of the electric stenciling process shows its method of operation. The discharge passing between the pencil and the brass plate perforates the paper producing small holes. The slower the pencil moves over the paper, the larger will these perforations be.

size: the faster the pen moves, the smaller will be the holes.

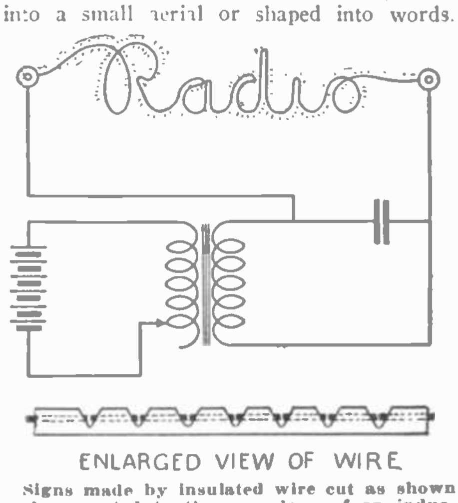
The stencils so prepared lend themselves to numerous and various applications, some of which are illustrated in the diagrams. By moving an ink-roller over the paper, a large number of impressions of this stencil can be made. They can also be used in electrical advertising display and even as slides in stereopticons.

Electric Sign

AN attractive electric sign can be made out of a spark coil, a few dry cells and some ordinary insulated copper wire, such as is used in house wiring.

The wire is cut as shown in the illustration. Sharp wire cutters should be used. These cuts are made every half inch. The copper center is cut entirely through and the ends should not touch. This can be done by slightly stretching the wire after it is cut. The insulation holds the short pieces of wire.

For show windows the wire can be made into a small aerial or shaped into words.



Signs made by insulated wire cut as shown and connected to the secondary of an induction coil form a spectacular display. Sparks passing over these small gaps between the segments of the wire produce a scintillating effect.

The spark coil is connected up and the wire connected in place of a spark gap. Each cut in the wire acts as a gap and the discharge produces a very striking effect.

Contributed by ROY C. HUNTER.

Fun with a Spark Coil

By Esten Moen

OH THE Old Spark Coil
She ain't what she used to be
Many long years ago.

Hey, you, cut that out! Pull down your old coil from the shelf, wipe off the dust, spit on your hands, and rub 'em hard. 'Cause here I dump off a big load for you to digest.

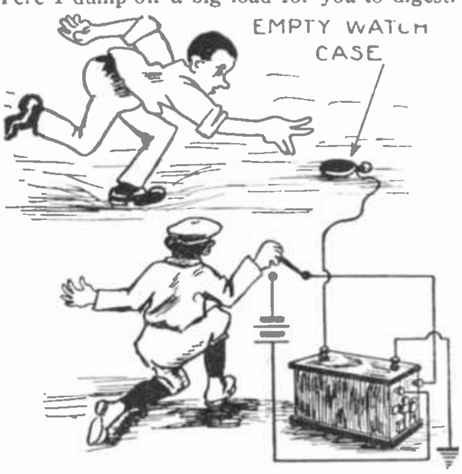


Fig. 1. The finder of the watch shown above will experience a shocking surprise when the primary of the coil is closed.

First, lem'me remind you of the fun you used to have with it in the good old days.

Then your coil—
She bit the dogs
And killed the cats
And spilled the soup
From the cook's big ladle.

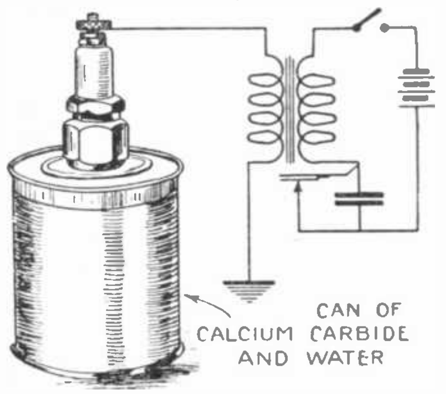


Fig. 2. The mixture of calcium carbide and water generates acetylene, which mixing with air in the can, is exploded.

By Jove! You remember when you tried that stunt shown in Fig. 1? 'Bout leadin' a fine wire to an empty watch case carefully laid on the sidewalk? Houly Bolls, but that made 'em jump!

Or perhaps you were less brutal and satisfied your infernal cravings with a cannon (Fig. 2).

But, on the other hand, when you finally decided on a murderous policy, you did invent something. You made an automatic shocker (such as in Fig. 3?) so it was harmless until pulled.

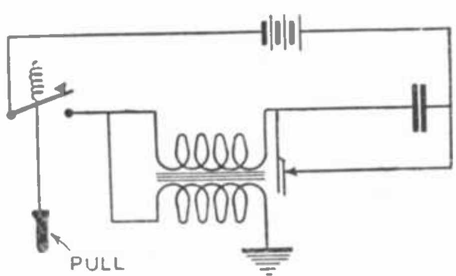


Fig. 3. Pulling the metal electrode attached to an apparent doorbell handle, closes the primary of an inductance coil and a shock ensues.

Or you gave the woman hanging wet clothes on the line, the scare of her life.

Not to be satisfied you keep on applying the old coil. F'r instance, you may have tried something similar to Fig. 4. A fishpond! You charge two nails for the privilege of fishing and then get more fun than a circus.

Little brother Dickie, watching you, perhaps understood the "invisible juice" more than you. He perhaps told you in his falsetto, that the high voltage of the coil should light the forty watt lamp that hung in the kitchen; because, he argued, the lamp operated on "high voltage".

And not to be daunted by your emphatic "NO" he proceeded to do it in front of your eyes.

And then indeed did your eyes open! For the bulb turned to a blue glow inside! But your ecstasy over, the discovery was cut short by Dickie dropping and smashing the precious bulb; and starting the yell of his life!

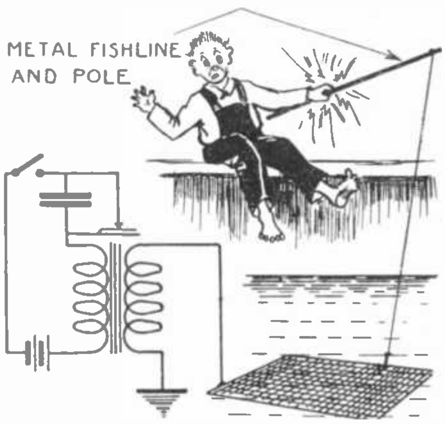


Fig. 4. Angling with a metal fishline and pole completes the secondary circuit of an induction coil, through a metal network in the brook.

As far as you were concerned, you forgot the lickin' and hunted up a burned-out globe, proceeded as in Fig. 5, thus perfecting your invention.

But now your idea box was empty, the coil had had its day, and you your play.

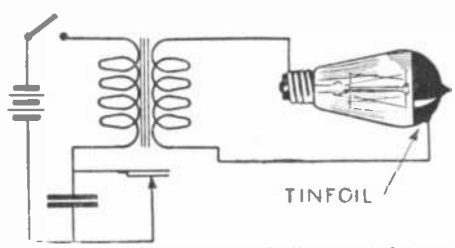


Fig. 5. An incandescent bulb conected to an induction coil, as illustrated, will glow with a bright blue color.

And now I'll disturb your peace of mind, by making bold to tell you, that you omitted an important and not to be neglected experiment.

Ever play with a water pump? Soak the kids and dogs? I mean one of those hand spraying outfits that work from one pail of water.

Now here's a stunt you ought to try. See Fig. 6.

You put the pump and pail on an insulated table. Connect coil to ground, and pail. Then you climb up on the table and there you be. Woe to him who meets the spray!

Let's go still further. On another table (as far from the first as you can squirt the water) put a ditto spark coil and—a metal screen as in Fig. 6.

To the primary of the coil we'll connect a small flashlight bulb. Now when the stream of water strikes the screen, it causes the light to shine, because . . .

Better use salt water for the experiment. (Don't forget to rinse the pump). Also screw the vibrator tight on spark coil. May I also suggest that perhaps you could have a series of screens and lights of different colors? Short of coils? Then use your Tesla coil.

If your first coil is of sufficient power

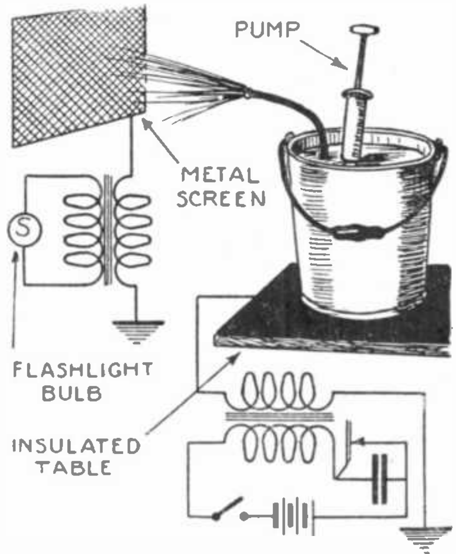


Fig. 6. By the arrangement shown above Esten Moen is supposed to transmit electricity over a water spray and lights a distant flashlight bulb.

perhaps the current received may be strong enough to run a toy motor (if the brushes aren't too tight).

Oh, "Jacob's Ladder!" Ever stumble onto it? Look at Fig. 7. Just two pieces

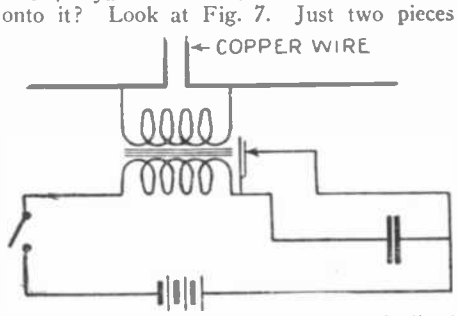


Fig. 7. Two copper wires somewhat inclined to each other are connected to the secondary of a coil. The spark starting at the lower end of the wires will rise to the upper end of the wires and vanish, and this is repeated over and over again.

of copper wire. Be sure they are straight.

I have one more stunt up my sleeve. Look at Fig. 8. A piece of glass, and one of tinfoil, a coin, an iodine vapor generator.

Put glass on foil, coin on glass, and connect to coil for a few minutes. Then expose glass to iodine vapor (or breath from the mouth) and the coin is reproduced.

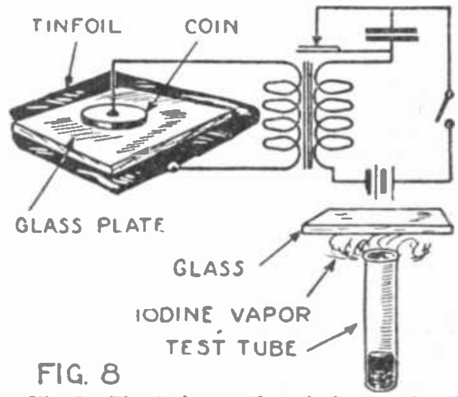
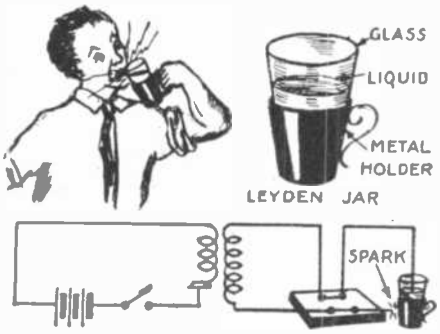


Fig. 8. The design on the coin is reproduced on the glass when the latter is exposed to iodine vapor after having been connected to an induction coil.

With your jackknife shave off a slice of the insulation along the full length of the wire. Lay it flush with the ground as shown, tape up one end and connect the other to your coil. Ground the other side of the coil.

Sure, there's leakage and capacity and what-not between the cable and ground, but if you think it doesn't work, build one and step on it!



The author claims that this drink has a genuine kick in it; the liquid within the glass and the metal holder without, constitute a Layden jar which is charged before the drink is handed to the innocent victim.

The best one comes last, but don't try it first if you want a longer lease on life. I tried it on a fellow once, but, you see, I'm a very good runner or I wouldn't be writing this.

This is a sure-fire way of getting away from Volstead and putting plenty of kick in that stuff you've got bottled up in the cellar. But you gotta serve your drinks in these soda fountain glasses with metal holders. Oh! Catch on? Sure! It's a Leyden jar! But don't charge the darn thing too much because of what I told you in the paragraph above.

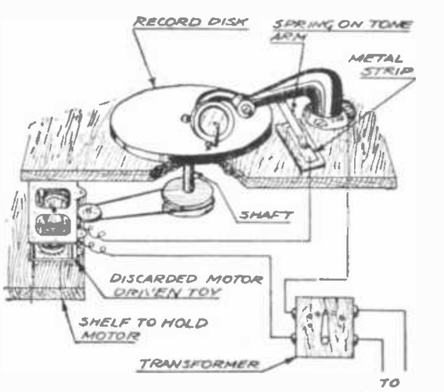
Electric Phonograph Motor

By Clyde E. Volkers

This arrangement disposes of the need of winding a phonograph and it stops automatically.

The most important piece of apparatus for electrifying the phonograph is the motor. This may be obtained from a discarded, electric, motor-drivn toy, such as a toy locomotive or street car. The transformer that accompanies it must be used also, in order to operate the phonograph on the city circuit.

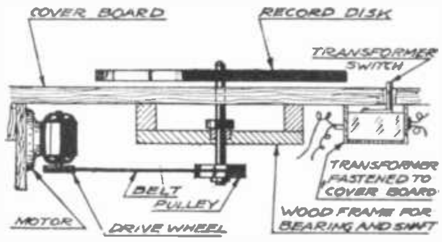
Remove all surplus parts, leaving only the framework, the motor itself, and one drive-wheel, which will serve as a pulley. Secure two narrow, tin or brass strips to hold the framework rigidly upon the shelf which has been placed beforehand, if the motor is one requiring a support other than the cover board.



A discarded toy motor can, by the ingenious experimenter, be installed in the ordinary phonograph and convert the latter into an electrically-driven one.

Remove the old spring motor from the phonograph. Secure a short length of iron rod, just long enough to bring the small pulley wheel on the lower end, in line, horizontally, with the drive-wheel of the electric motor. This pulley wheel should be fastened to the rod by means of a set screw. The upper end of the rod should fit into the socket provided for it in the record disc.

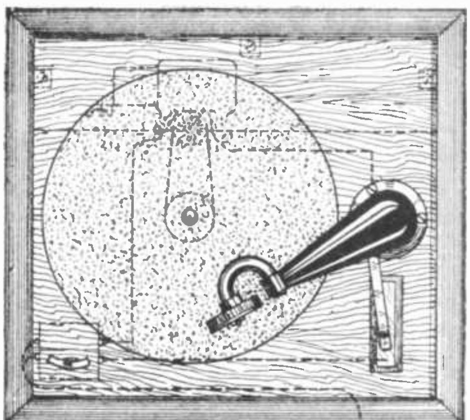
The shaft is held rigidly in position by means of a strip of wood about 1 by 2 inches, and long enough to reach an inch beyond each side of the shaft. Blocks of wood fastened to the cover to serve as brackets under each end of the strip. A hole is drilled through this strip to admit the shaft, and permit it to revolve without touching the wood. Drill a larger hole about half way through the strip. In this is to be placed a brass bushing whose inside diameter will admit the shaft snugly. This bushing serves as a bearing. A small collar with a set-screw is placed on the shaft above the bearing to keep the shaft from working downward, and away from the record disk or table. A belt of leather



The figure shows another view of the motor and connections for driving the ordinary phonograph electrically; the motor is connected to a 110-volt supply line through the usual toy or bell ringing transformer.

or rubber should be placed over the drive-wheel and the pulley on the end of the rod.

Bring one wire from the motor to one



A strip of spring metal pressing against the tone arm of the phonograph maintains contact with the latter and keeps the electrical circuit closed until the needle has reached the end of the record.

binding post of the transformer. Lead the other wire from the motor to the cover board which supports the tone arm, allowing an inch or so to project above the board. We will finish with this wire later.

Now bring the other wire from the transformer to one of the screws in the base of the tone arm and slip it under the head of the screw. This makes a good contact with the metal of the tone arm. A double-wire cord and plug should be connected to the other two binding posts of the transformer. When all work is completed, the plug is placed in an electric wall-socket.

The automatic stop will stop the motor when the record has finished playing. A long narrow strip of brass, about 4 inches in length, is countersunk flush with the surface of the cover board. A binding post has been bolted through the end farthest from the tone arm. This strip should be placed so that when the tone arm has reached the position at which the record has finished playing, the spring that slides along this brass strip will have just come in contact with the wood of the cover board, thus opening the circuit and stopping the motor.

The spring should be of spring brass. It

This external view of the converted electrical phonograph shows that the electrical installation has in no way impaired its appearance. Through the crank-bearing the supply wire is led to the base plug.

is soldered to the tone arm. Now connect the wire projecting a few inches above the cover board to the bolt in the brass strip.

Make an arc on the cover board to correspond with that through which the speed control lever of the transformer moves. Cut out this small arc with the keyhole saw. Place the transformer in position on the under side of the cover board and fasten by means of two metal strips held by screws at each end. The transformer lever opens or closes the circuit, and controls the speed of the motor.

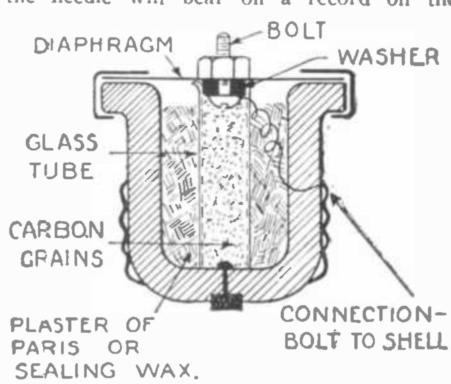
Fuse Plug Transmitter Button

THE transmitter button shown here is made out of an old fuse plug.

The type of plug that has a mica window is used. The brass retaining ring is removed carefully so as not to break the mica. A hole is drilled in the center of the mica diaphragm in which a small bolt is placed with a small washer under the head. This washer fits loosely inside of a glass tube filled with granulated carbon or better yet regular transmitter carbon granules.

A connection is made from the shell to the bolt with a fine wire.

A home-made audio transformer may be tested by fixing a phonograph needle on the diaphragm button. Then place it so that the needle will bear on a record on the



An effective and sensitive yet very simple microphone can be constructed from a discarded fuse plug. An axially located glass tube filled with polished carbon grains forms the principal part of the device.

phonograph. Connect up as shown. If the transformer is O. K., the music will come through clear and undistorted.

—Contributed by Wm. V. Gilpin.

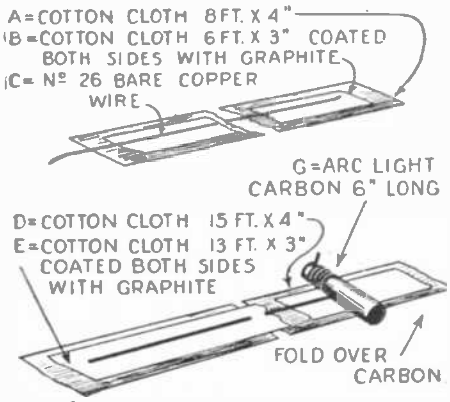
Secondary "Gas" Battery

By W. J. Edmonds

An experimental secondary battery which in reality is a "gas" battery having many peculiar properties of interest, may be easily constructed at practically no cost.

For the battery four strips of cotton cloth A, B, D, E should be provided. The strip (A) is 8 feet long by 4 inches wide, the strip (B) is 6 feet long by 3 inches wide, the strip (D) is 15 feet long by 4 inches wide and the strip (E) is 13 feet long by 3 inches wide.

The strips (B) and (E) are placed in a small receptacle containing powdered graphite and are stirred around until each strip is thoroughly covered with the graphite. The strips are then taken up and the excess graphite is wiped off, so as to leave the strips with a coating on both sides of a metallic lustre.



Preparing cloth with a graphite coating and rolling it up with an embedded copper wire to produce a gas battery.

The two uncoated strips (A) and (D) are placed on a flat surface and the two coated strips (B) and (E) are laid one upon each of the other strips, as shown, so as to leave an equal exposed margin of the uncoated strips extending beyond same along their entire edges. Upon the strip (B) a 6½-foot length of No. 26 bare copper wire (C) is placed running the length of it with 6 inches of the wire extending beyond one end of the strip. A second copper wire (F) 13½ feet long is placed upon the other coated strip (E).

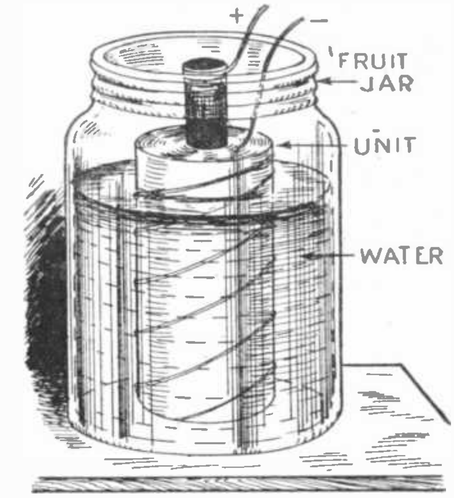
The projecting end of the copper wire (F), which is 6 inches long, is tightly wound around the carbon rod (G), which is taken from an arc light. The carbon rod is laid squarely across the adjacent end of the strip (E) so as to make a good contact with the graphite. The rod (G) is so placed as to allow about 6 inches of the strip (E) to project beyond. The extending portions of the strips (D) and (E) are folded back over the carbon rod so as to cover it. The two strips (A) and (B) with the copper wire are placed in position upon the strips (D) and (E) centering them lengthwise in relation to these strips and bringing their long edges flush with these strips.

With the carbon rod G as a spool or roller the four strips and two strips are tightly rolled up so as to have the shape of a cylinder. A length of thread or string is wrapped around the roll so as to hold the various parts together in position. The roll with its two projecting wires is placed in an old straight-sided fruit or battery jar and the jar is filled with water to within a half inch of the top of the roll.

This completes the construction of the battery which may be charged from a series of ordinary cells by connecting its zinc pole with the carbon pencil and the remaining pole to the other protruding wire. After being charged for a period of half an hour or so the batteries may be disconnected, when it will be found that the battery will yield a current.

This battery in the true sense of the word is a "gas" battery as well as a secondary or storage battery. On being charged the current sent through the cell causes the water contained therein to decompose into its two component gases, hydrogen and oxygen. The hydrogen is held in its free state as a gas within the cloth of the graphite coated strip (E) and the oxygen is held within the strip (B). The strip (E) holding the hydrogen, about twice the size of strip (B) which holds the oxygen.

When a quantity of oxygen and a quantity of hydrogen are subjected to the same physical conditions they will present relatively to each other a difference of potential; therefore, after the charging when a conducting path is established between the strips, the two gases recombine forming water, and a current is generated.



The gas battery having the cloth wrapped around it in a spiral gives the requisite surface for the gases to collect on—one gas is oxygen, the other is hydrogen.

Our Clock Problem

In the February, 1925, issue we presented a problem from one of our readers, Cecil Manners, and offered a $10.00 prize for its solution. For the benefit of those who did not note this problem we are presenting it below in Fig. 1.

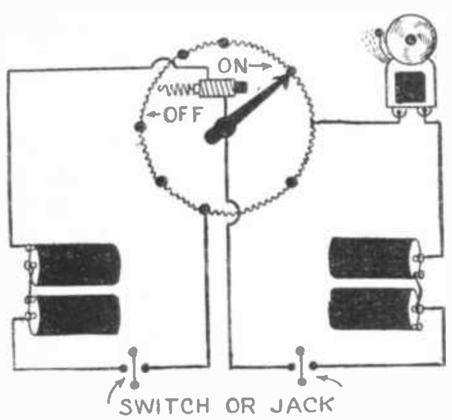


Fig. 1 is the original problem as given by Cecil Manners in our February issue. Mr. Manners desired a clock that would ring a bell, and the time limit for ringing could be varied according to the desire of the operator.

It is desired to operate a machine that needs various attention within an hour. During the time the machine is in operation the clock must run and keep time. At the end of the operation, a bell should ring upon the specific time set by the operator. When the clock-hand reaches this point, it must make contact and ring the bell. The period during which the clock is to ring should be adjustable, from a few seconds to several minutes. It is the desire of the operator to be able to regulate this clock for practically any time of the day.

The method shown in Fig. 1 will not answer the purpose because when the operator starts the machine the bell will continue ringing until the hand passes over the contact point, which ringing may last a quarter of a minute or more. This is undesirable.

Hundreds of letters were received, each one presenting a different solution to the problem. Of course, a problem of this type may lead into many complications and conversely there are many complicated ways of solving it. It is the aim to use as simple apparatus as possible, obviously, so that expense will be at a minimum.

Despite the fact that we received so many solutions, singularly none of them fulfilled the requirements. All kinds of suggestions were received. Some even went so far as to use a separate switch board arrangement with multi-contact switches on high tension circuits. Some used mercury contacts actuated by gravity, and some even employed an additional clock. The solution is very simple, as Fig. 2 shows.

A small semi-triangular metal object is to be placed at each hour point of the clock. These triangular pieces slip in and out of a groove, so that the time for the ringing of the bell may be varied.

When the piece is moved further into the groove, so that a greater portion of the triangle is exposed to the contact of the hand the bell will ring for a longer period of time. The exact period of time for each movement of this metal piece may be determined by experiment and may even be calibrated, if desired. The illustration is self-explanatory and, as stated above, the apparatus is very easily built.

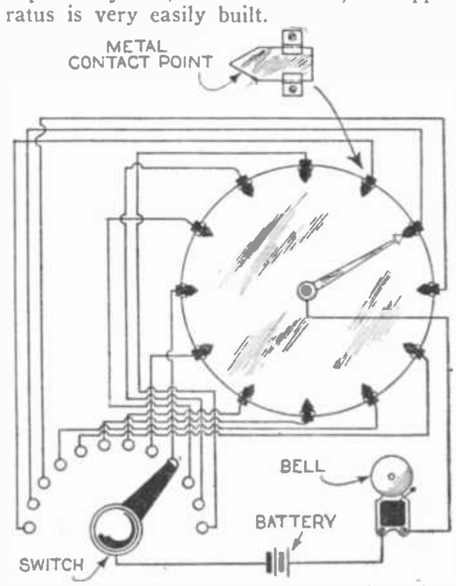


Fig. 2 is our solution of the problem since none of our readers submitted a practical or satisfactory answer.

We want to thank our readers for the interest taken in this contest, although no suitable solution was given. We promise more problems of this kind from time to time, with bigger and better prizes.

If our readers have an interesting electrical or radio problem they desire solved, it shall be our pleasure to do our utmost towards this end.

Awards in the $50 Special Prize Contest

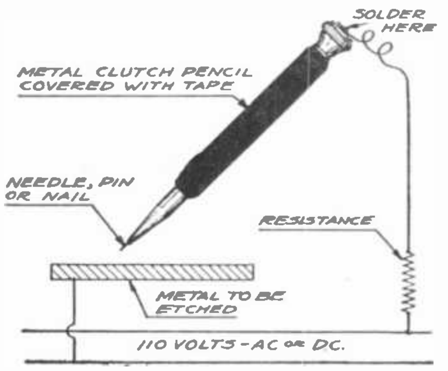
For Junior Electricians and Electrical Experimenters

First Prize, $25	Second Prize, $15	Third Prize, $10
F. R. Moore	D. Oscar Turnbull	Carl Fischer
2516 Baker St.	5063 Page Bl.	Rt. 3, Box 81
Detroit, Mich.	St. Louis, Mo.	Chico, Calif.

First Prize
Electric Etching Pencil

THIS is an electric etching pencil for the experimenter who wishes to do small soldering, etching or welding jobs on his radio battery or other articles.

The requisites for its construction are: (1) A metal "clutch" pencil (so-called, because it holds and releases the "lead"); (2)

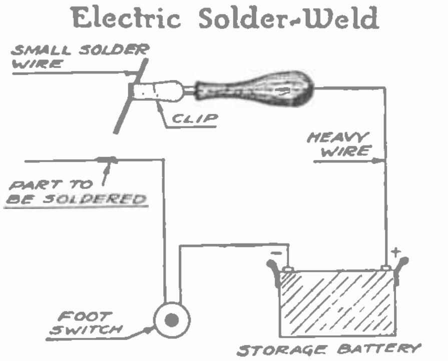


The familiar Ever-ready metal pencil is here made to etch upon metal by the lighting circuit. The pencil must be carefully insulated to protect the user, who otherwise may get a bad shock.

a resistance suitable for 110 volts A.C. or D.C. (ten or fifteen feet of No. 22 nichrome resistance wire wound around a porcelain or asbestos tube is fine for this purpose); (3) and some scrap pieces of No. 14 house wire for making connections.

The "clutch" pencil is well insulated by winding several layers of tape around it. When this has been done, a common phonograph needle is inserted and held in the tip of the pencil, and it is ready for use. It may be necessary, however, to slightly wedge the needle in the pencil tip with a splint of wood. Connections should be made tight and as shown in diagram.

Second Prize
Electric Solder-Weld



This may figure almost as a variation on the above. A low potential battery circuit is connected to a bar of solder which forms one of the electrodes and melts when, on touching a plate of metal, it completes the circuit.

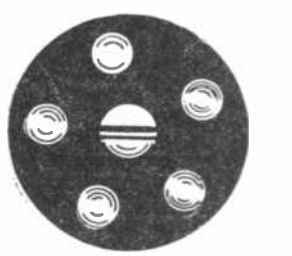
THE solder-weld is operated from a regular 6-volt storage battery. The materials necessary for construction are: An insulating handle with heavy metal clip to hold the solder wire, and some heavy insulated wire and a metal clip to connect the material to be soldered. When heavier solder wire is used on an A.C. circuit, a small step-down transformer is necessary and a foot switch is used to keep the transformer from heating so quickly when used at intervals.

This is quite an interesting suggestion and capable of considerable modification. The wire may be varied in thickness and it will be quite advantageous to use self-soldering wire, which is a wire containing its own flux. There is even a suggestion of the possibility of brazing by this method, and brazing is one of those things which every experimenter wants to do, as a good brazed joint is of very great strength. The possibility of brazing on the small scale extends considerably the field of amateur operation.

> **$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 submit 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.

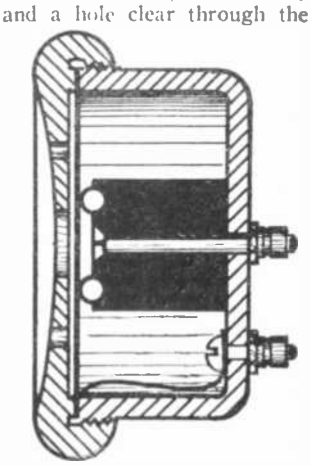
When the solder wire is brought into contact with the fluxed wire to be soldered, the point melts almost instantly. The device can be used in a great many places that an iron cannot reach. For successful operation it is necessary that the battery be fully charged.

Third Prize
Multi Contact Microphone



The end of a battery carbon drilled with five holes for the reception of polished grains of microphone carbon or of carbon balls. These are supposed to bear against the carbon diaphragm.

THIS microphone may be easily and cheaply made by the experimenter. Any receiver shell will serve as a case. A carbon rod from a dry cell is sawed off a bit shorter than the depth of the inside of the shell. In one end of the section of the rod drill five small holes, each about $\frac{3}{32}$-inch deep, and a hole clear through the middle.

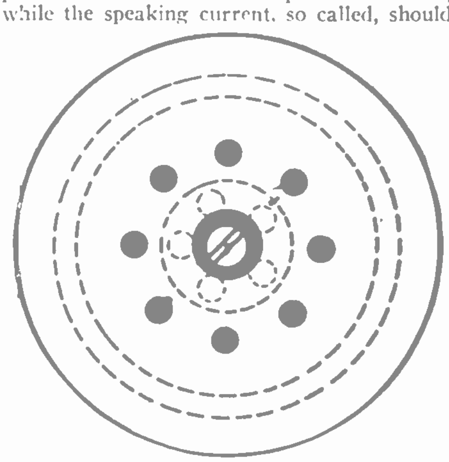


The section of the microphone contained in a telephone receiver case. The relation of carbon center piece bolted to the back, the balls and the diaphragm, are all very clearly shown.

On the inside of the shell, as shown in Fig. 1, the rod is fastened so that the carbon will be held firmly. A piece of sheet copper or brass about ⅛-inch wide placed flush with the edge of the shell is led to a binding post. This makes contact with the carbon diaphragm.

All that is left to do is to fill the five small holes with carbon balls or grains, put on the diaphragm, and screw on the cap. C is the carbon and D the diaphragm, in the diagram.

One of the great points made about the telephone in early law suits was that the circuit must never break. Every time a telephone circuit is broken it produces a tick, while the speaking current, so called, should



Front view of the microphone, showing the general distribution of parts.

never be suddenly broken, but should simply pass from one potential smoothly to another, even if in so doing it passes through the zero value. But this does not imply any sudden break, and in this instrument the carbon contacts give an unbroken contact.

What Our Readers Think

More About Ball Lightning

Editor, EXPERIMENTER:

The author of "Ball Lightning Made in the Laboratory" in your issue of February, 1925, page 284, is skeptical regarding its existence and is inclined to believe in some sort of "psychological phenomenon" theory. The following account of my experience may cause him to doubt his theories and hold his opinions in abeyance.

About 12 years ago, while ocean bathing, a sudden storm came upon Atlantic Highlands, N. J.; rain fell in torrents accompanied by many flashes of lightning and loud thunder. For a while I remained under a pier until the temperature suddenly dropped and, being sensitive to cold, I decided to go to my bath house, which was about 300 feet from the pier. While discarding my bathing suit, there suddenly appeared, whirling about me with great momentum, a reddish blue mass, about the size of a Rugby football. I could feel the "breeze," as it seemed, but was too terrified to note whether it was hot or cold; the sound emitted was a note of the middle harmonic. In fright, I jumped on the seat of the bath house and watched the strange visitor circle around for a few seconds and then disappear underneath the door. A few seconds later a deafening noise was heard. I dressed *very hastily* and retreated to my hotel close by.

After the storm was over, I started to investigate and found a thick wooden pile broken off complete transversely which had extended above the pier floor. This pile was in a direct unobstructed path to the door of my bath house locker. Those who had remained under the pier during the storm related their terrifying experience and all complained that they could not hear or see for a few minutes after the blinding flash. Various accounts were given as to the exact path, but the consensus of opinion was that it descended in the form of an arc, taking a path into the sea. The wood from the broken pile I found about 600 feet distant from the pier.

I also recall that after the ball lightning (or whatever it may be called in the future) left the bath locker or room, that the air had an odor as if ozonized.

If further and more complete data is wanted on the phenomenon which I have had the good fortune to see and experience, I will give it to the best of my ability.

Very truly yours,
HERMAN L. BERGER.

Jersey City, N. J.

Ball Lightning

Editor, EXPERIMENTER:

In regard to an article on "Ball Lightning" appearing in the February EXPERIMENTER of 1925, I would like to state that I believe that what Mr. Waynes Polo of Astoria, Ore., saw was the phenomenon most commonly called "Will o' the Wisp," and for further particulars I am inclosing an article clipped from a newspaper which describes it in full detail.

If you compare his letter with the clipping, I think you will agree with me.

Also in regard to the letter by Mr. C. H. Stowe of Paris, Texas, I would like to state that I had the same experience as he had, except that the ball of lightning was larger or appeared to be so. It was about the size of a common tea cup.

Yours truly,
ERNEST C. FREY.

Lincoln, Neb.

The following is the clipping alluded to above:

Strange Lights Are Explained By Scientists

Vermilion, S. D.—Balls of fire, floating at night over the northern prairies of Nebraska and in various parts of South Dakota, terrifying some of the more superstitious inhabitants who believe that the world is about to come to a fiery end, have aroused the interest of scientists at the University of South Dakota, whose explanations should allay the fear of even the most superstitious.

These strange lights that appear on cloudy nights and are keeping ranchers near O'Neill, Neb., and inhabitants of Pennington county, South Dakota, in a state of constant uneasiness, are really nothing more than bubbles of marsh gas oozing out from the swamp land and catching fire as they emerge, according to Freeman Ward, state geologist and professor at the University of South Dakota. They are commonly known as the "Will o' the Wisp," a phenomenon that has been frequently seen in nearly every part of the world.

The Flewelling "Super"

Editor, EXPERIMENTER:

In the EXPERIMENTER magazine of the January issue there is an article regarding the Flewelling super-regenerative set.

I have constructed this set with comparatively good parts, and get comparatively good results; but it is necessary for me to eliminate the ½ megohm grid leak on the .006 condenser, as this grid leak will almost kill all the incoming signals. I have constructed quite a number of sets of the Ultra-audion and Reinartz type, and am therefore no greenhorn in construction. My wiring is all bus bar, and all square and firm. Thus the possibility of faulty wiring is out of the question. Could you either give me the address of the gentleman who wrote this article, or simply forward this letter to him. His name is Rufus T. Turner; but his address is not given. I am taking for granted that you possess his address in your files. His article is on page 160 of the January issue of THE EXPERIMENTER.

The results I have achieved so far have convinced me that the Flewelling "Super" is capable of extraordinary good service when in good working order, even if the signals are a trifle unstable.

The only bug bear is the setting up of the three .006 condensers and grid leak. I have not had any experience regarding these, and so have no real idea where they are to be placed, or in what relation to each other, whether close or far apart.

I am not a subscriber to your magazines, but I have so many copies of *Science & Invention*, *Practical Electrics* and especially *Radio News* at my right hand that I feel that you would be willing to render me a slight favor.

Yours sincerely,
HERBERT M. DAENZER.

St. Louis, Mo.

(*Doubtless, the half megohm grid leak that you say must be abandoned in order that signals be heard, is too large and therefore should be of a one to three megohm resistance. A variable grid leak will enable you to determine the exact resistance at which the tube operates most efficiently. It is very important that the three .006 mfd. condensers be exactly the capacity indicated and not vary the slightest if perfect reception is to be attained.—EDITOR.*)

Fleming's Rule—A Correction

Editor, EXPERIMENTER:

I am sending what I believe to be a correction of Harold Jackson's article on page 188 of the January, 1925, EXPERIMENTER.

The application of the "Fleming hand rule" of electrical energy shows induced e.m.f. in wire passing or moving downward across a south pole to be toward the right instead of toward the left as in the diagram on page 188.

I have found that it pays to watch this in assembling radio sets; so that the waves that induce e.m.f. in the aerial also induce an e.m.f. in the coils in a set, you must see to it that one does not buck the other.

Yours truly,
M. E. CURTIS.

Scotia, Cal.

A Nice Ending to a Nice Letter

Finally I want to tell you that the EXPERIMENTER is getting better and better every month and I don't want to miss one issue.

Yours truly,
ELMER F. HOFFMAN.

Dunellen, N. J.

A Reader of Our Four Magazines

Editor, THE EXPERIMENTER:

I wish to take this opportunity to say that, for eight years, I have been a constant reader of the four publications of the Experimenter Publishing Co., and have invariably found them instructive, entertaining and reliable.

Yours truly,
JOHN KINZER.

Stevens Institute,
Hoboken, N. J.

Another Appreciation of Our Chemical Department

Editor, THE EXPERIMENTER:

I enclose herewith a cutting from the "Hamilton Spectator" of Feb. 21, which I think would be a suitable contribution to your "Short Circuits."

You seem to be getting so many letters of congratulation on your new issue that I must add mine. I dropped the old magazine for a while, but am very much interested in the new magazine especially the chemical departments. I also take "Science and Invention," and would like to see more chemistry in both of them. I am a student of The Chemical Institute of New York, one of whose principals has a very interesting article in the February issue of the EXPERIMENTER, the article containing material that I will be studying soon. I refer to the article by Mr. Woods.

Wishing you every success, I remain

Yours sincerely,
R. N. J. PETERS.

Hamilton, Canada.

Better Than the ELECTRIC EXPERIMENTER

Editor, THE EXPERIMENTER:

I have bought the last four copies of The EXPERIMENTER and am very well pleased with it. I was sorry to see the old ELECTRICAL EXPERIMENTER pass, but this has taken its place and is even better.

I have one suggestion to make and that is to print the data sheets, which are now being printed, in such a manner that when placed in the loose-leaf notebook it will not be necessary to turn the book upside down in order to read the data on the back side of the sheet.

I am extremely interested in electro-chemistry and have wondered why you have not edited a book on this subject, using the articles that have appeared in your magazines. I would like to own one if there is such a book.

Very truly yours,
J. LAURENCE TOWNSEND.

So. Portland, Maine.

The EXPERIMENTER in the High School

Editor, THE EXPERIMENTER:

I purchased my first copy of the PRACTICAL ELECTRICS last September, just in time to be informed that its name was to be changed to the EXPERIMENTER.

I was so well pleased with the PRACTICAL ELECTRICS that I was bound to get the EXPERIMENTER, which I from then on put on my magazine list.

I am a student of junior rank in Barberton High School and also a student of a well known correspondent school where I am taking an electrical course.

We have organized in our school two very popular clubs, the Junior Science and the Radio, of which I am secretary and treasurer. I have introduced the EXPERIMENTER into both of these clubs and may say that the best and most interesting ones are received from the readers of the EXPERIMENTER.

I heartily recommend the EXPERIMENTER to all.

Yours for better success,
CHARLES FISHER.

Barberton, Ohio.

Wants More Chemistry

Editor, THE EXPERIMENTER:

I am a constant reader of the EXPERIMENTER and am very pleased with it. I can say that the EXPERIMENTER is getting very good and suits me down to the ground. I would suggest a few more pages of chemistry as I am very much interested in the subject.

Yours sincerely,
I. BERCOVITCH.

Montreal, Que., Canada.

One of Our Ardent Readers

Editor, THE EXPERIMENTER:

I am an ardent reader of your magazine and enjoy it very much, especially the articles dealing with chemistry.

F. L. BUCHANAN.

Middletown, Ohio.

A Good Word for the EXPERIMENTER

Editor, THE EXPERIMENTER:

Well, you certainly must be tired after the three experiments I sent in. I suppose I won't get a prize for any one of them, but it's worth while trying. Yes, sir, I sent one experiment to the *Radio News*, the second to the EXPERIMENTER, and the third to the *Science and Invention*. And you can bet your last dollar that if I knew anything about autos, there would be one for *Motor Camper and Tourist*. I have taken the former three every month for the past year and now I have some reference library, believe me. My folks go wild. All they can see around the house are radio magazines, station logs and technical books on radio.

After I get through looking over *Radio Digest* and *Radio World*, I turn back to *Radio News*, for it is the best of them all. And the EXPERIMENTER is a wonder, too. *Science and Invention* is not far behind either.

Well, let's hope for the best in radio.

Sincerely,
CYRIL A. BART.

Buffalo, N. Y.

Nothing Like It

Editor, THE EXPERIMENTER:

There is nothing like the EXPERIMENTER, especially on chemistry, in which I am greatly interested. I would like it much better if there were more about chemistry in it.

Wishing it a hearty success, I remain

Yours truly,
HOWARD S. BABCOCK.

Saginaw, Mich.

The Junior Experimenter to the Fore

Editor, THE EXPERIMENTER:

Nearly every day I am working and experimenting with things pertaining to electricity. Later on I expect to send you some more of them. I am interested in all parts of your magazine, but like your "Junior Experimenter" the best.

Yours for success,
F. ALTON EVEREST (Age 15).

Portland, Oregon.

A 100% Magazine

Editor, THE EXPERIMENTER:

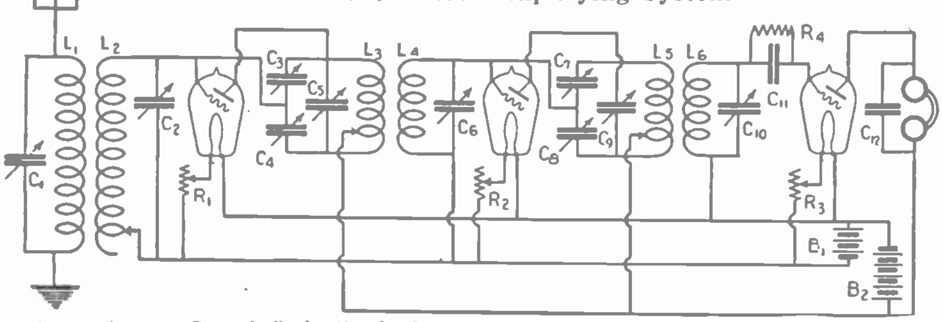
The EXPERIMENTER is a real 100% magazine and I hope it lasts forever.

Yours truly,
DEFOREST UREY.

Sandy Lake, Pa.

Latest Electrical Patents

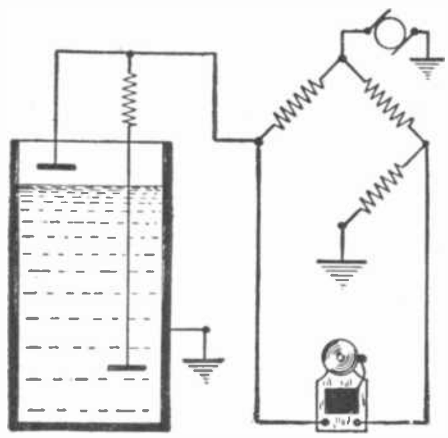
Neutralized Amplifying System



The condensers C_1 and C_8 in the hook-up are employed to neutralize the effect of plate-grid capacity. The condenser C_3 and C_7 are supplemental capacities connected across the grid and plate of the tubes, in order to increase the natural grid-to-anode capacity of the tubes so that the resultant capacity may be increased to a practicable value.

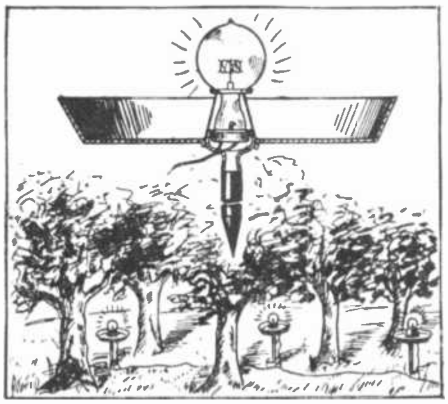
Patent No. 1,524,581 issued to J. Scott-Taggart, Ilford, England.

Tank Alarm



This invention is in effect a Wheatstone bridge, one arm of which is constituted by the water lying between an electrode and the walls of the steel tank. As the water rises and reaches the predetermined level, it comes in contact with another electrode and unbalances the bridge. At this moment an electric bell connected in the bridge circuit rings.

Patent No. 1,520,004 issued to F. G. Bloch, Boldingen, Germany.

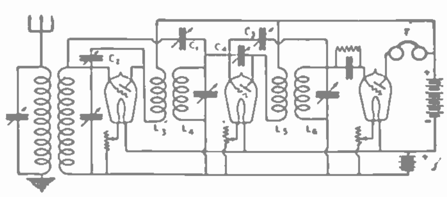


Insect Trap

This device, of questionable utility, was designed to attract insects by a brilliant light source and then to scorch them when approaching the same. A large receptacle is provided for the collection of the maimed insects.

Patent No. 1,521,323 issued to J. W. Reeder, Spokane, Wash.

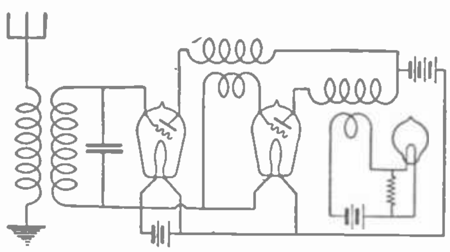
Vacuum Tube Amplifier



By means of the amplifying circuit shown, the ratio of amplification can be varied without varying the impedance presented by the amplifier as a whole to the impulses which are to be amplified. This is accomplished by the use of a variable impedance shunted across the terminals of the secondary of the transformer used between two stages of amplification.

Patent No. 1,520,994 issued to H. D. Arnold, Maplewood, N. J.

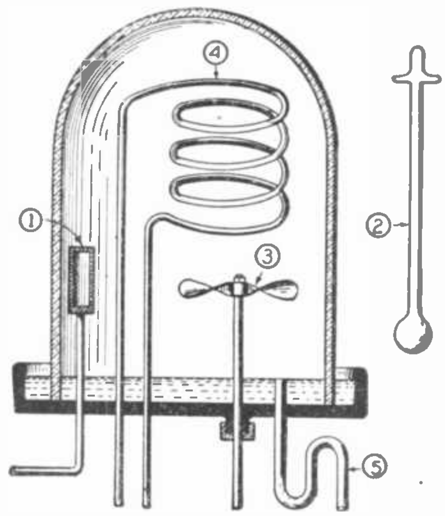
Photoradio-Receiver



The output of the last tube in this receiver supplies energy to a small incandescent lamp, the rays from which are directed to a photographic film on which the varying intensities of illumination are received. The film is then developed and used in connection with a selenium cell to transform its record into sound.

Patent No. 1,522,305 issued to M. Latour, Paris, France.

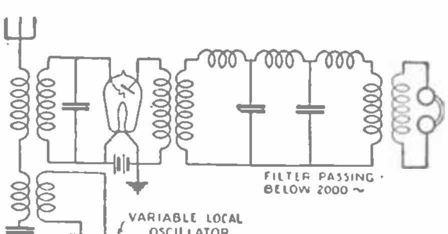
Photochemical Process



Certain chemical reactions are accelerated under the influence of actinic rays, especially reactions between hydrocarbons and halogens yielding liquid products. To this end the gases are introduced into the glass dome through a porous cup (1), and under the influence of rays from lamp (2), they are agitated by a fan (3), and cooled by water circulating in the tube (4). The liquid products are removed through tube (5).

Patent No. 1,523,563 issued to Walter O. Snelly, Allentown, Pa.

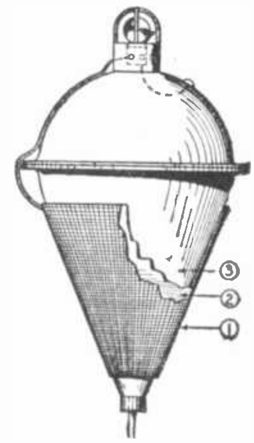
Secret Radio Receiver



A common practice in secret radio transmission is the inversion of the speech frequency band at the sending station and its reinversion at the receiving station. In view of the usual form the receiving comprises at least two distinct steps; first, the detection of the carrier waves to receive the inverted speech band, and secondly, re-inversion by modulation to restore the signals to intelligible form. The present invention effects detection and re-inversion by the use of a heterodyne receiver in which the local oscillator is tuned to the frequency difference between the carrier frequency and the local oscillation frequency of the transmitter.

Patent No. 1,522,044 issued to R. Bown, East Orange, N. J.

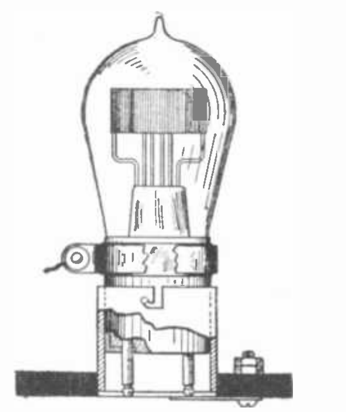
Automatic Marine Signal



The marine signal bell mounted on this buoy is supplied with power from the battery consisting of the steel buoy and a copper network as electrodes with the sea water as electrolyte. The two electrodes are separated from each other by a layer of canvas.

Patent No. 1,522,121 issued to J. K. M. Harrison, Ogontz, Pa.

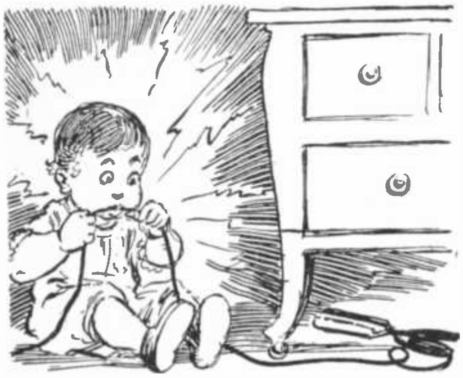
Simple Grid Condenser



In this attachment to a vacuum tube the capacity between a metal band clamped around the base of the tube and the metal parts inside is employed as grid capacity. In this way the necessity for making special connections to the grid condenser is eliminated.

Patent No. 1,523,893 issued to Robert C. Pitart, Jackson, Miss.

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!



Child Bites Cord of Electric Tongs

Canadian Press Service

Toronto, Feb. 21.—A victim of a peculiar accident, Jackie Griffen, two years old, son of Mr. and Mrs. J. W. Griffen, lies in a serious condition at the hospital for sick children. The child bit the cord of an electric curling tongs, sustaining severe burns to his mouth. He received a heavy shock, and it required two minutes to pull the cord from the child's mouth. A sister turned the electric light switch off.

Several blood transfusions have been given in an effort to save his life, and it is now thought he will recover.

This is the grave
Of little Baby Peter.
He bit a cord which carried
High voltage from the meter.
—*R. P. Peters.*

This is the grave
Of Lionel Spencer.
For aerial he used mains,
But forgot the condenser.
—*Harold N. Dawson.*

66,000 VOLTS KILL CAT

Animal Climbs Pole Near Vale and Is Electrocuted.

VALE, Or., Feb. 18.—A full-grown bobcat was electrocuted on the 66,000-volt line of Vale Electric company, between here and Nyssa. Ted Knowles found the animal as he was patrolling the line and said while getting the bounty that the huge cat climbed the 50-foot pole and got its face against the top wire while its legs were around the ground wire which runs the length of the pole.

The animal had taken the entire lead through its body, blowing the fuse on the line.

Here lies the body
Of Thomas, the cat.
High tension circuits
Ran where he sat.
—*Jeremiah L. Backwater.*

being given daily.

Pigeon Short-Circuits Car and Light Wires

Special to The New York Herald Tribune

WASHINGTON, Pa., June 11—In some manner a pigeon formed a contact between two high-tension wires of the Pittsburgh Railways Company near Monongahela City, this county, to-day, causing the wires to explode and fall across the lines of the West Penn Power Company and short-circuiting both trolley and power lines.

For five hours a district of several square miles was without electric light and all streetcar traffic was halfed. The charred body of the pigeon was found suspended from one of the high-tension lines.

This is the tomb of
Mary McAllison Dore.
She put her finger in the plug
She'll put it there no more.
—*Roger E. Bender.*

Shock From Electric Hair Dryer Kills Woman

DES MOINES, Ia., April 1.—Mrs. Grace Zucker, wife of a Des Moines business man, was electrocuted by a hair dryer immediately after she came out of the bathing pool at the Jewish community here. Her hair was wet from the plunge and caused an abnormal shock from the dryer, which usually carries only a small voltage.

Beneath this earth
Lies John McLoosed.
The barber chair was grounded
When the clippers were used.
—*William F. Eckert.*

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.

Davy Safety Lamp

(513) John Worznik, Pittsburgh, Pa., inquires:

Q.—What is the principle of the Davy miner's lamp?

A.—The Davy lamp is essentially an oil lamp surrounded by a fine wire gauze instead of the usual chimney. Such a lamp taken into a chamber filled with explosive gases will not cause explosion because the gas entering the lamp will burn inside, but no flame will reach the gas without, the wire gauze acting as a cooling medium between the flames and the gas outside the lamp.

The principle on which the safety lamp depends can be shown by a simple experiment. Light a Bunsen burner and lower over the flame a wire gauze. You will note that the flame does not extend above the gauze, but spreads out below. Turn off the burner and place the wire gauze about two inches above it, then turning the gas on again apply a match above the gauze. The usual Bunsen flame will be formed above the gauze but no flame will be observed below it.

The construction has been much modified and glass is sometimes used to surround the flame while the air supply and the escaping products of combustion have to pass through wire gauze. The idea is that even an explosive mixture will not be ignited by a flame shielded by wire gauze.

Calculation of Capacity

(514) Jack R. Lambert, Hot Springs, Ark., inquires:

Q. 1.—Is there any value of condenser capacity that can be connected to a variable condenser of 43 plates to give a capacity of the same value as a 23-plate condenser?

A. 1.—The 23-plate condenser has a capacity exactly half that of a 43-plate condenser. By connecting two 43-plate condensers in series, the capacity of the two together will be equivalent to that of a 23-plate condenser.

Q. 2.—Can you give me a simple way to calculate the capacity of a fixed condenser?

A. 2.—The capacity of a condenser is expressed by the equation—

$$C = .000,000,088 \times \frac{nA}{l} \times k \text{ mfd.}$$

Where (k) is the dielectric constant of the medium between the plates of the condenser, (A) is the area of one plate in cms., (n) is one less than the number of plates and (l) is the distance between each pair in cms. The constant (k) is 1 for air, and about 3 for mica; for glass it ranges from 5.5 to 10, and for dry paper from 1.7 to 2.6.

Thus the capacity of a condenser having 43 plates each having an area of 54 sq. cm. and separated by spaces of 0.2 cm. is—

$$C = .000,000,088 \times \frac{42 \times 54}{.2} \times 1 = .001 \text{ mfd.}$$

approximately.

The same condenser using mica for dielectric will have a capacity .003 mfd. and one using glass having a dielectric constant of 6 will be .006 mfd.

Dielectrics

(515) Juan Lopez, Vera Cruz, Mexico, writes:

Q. 1.—In reading through various articles in THE EXPERIMENTER and the *Radio News* I found frequent references to condensers of various sorts, such as oil, mica, glass, paper, etc. I am familiar only with air condensers, such as those used in radio apparatus and would, therefore, appreciate some information on the other types.

A. 1.—Condensers are made with three different classes of dielectrics: gases, liquids and solids. The first two of these are used in the so-called variable condensers, while the last is employed in condensers of the fixed or adjustable type. We may also mention condensers using vacuum between plates, but the characteristics of this type are almost exactly the same as those of a condenser using dry air for dielectric.

Among liquid dielectrics oil has found most extensive application. Oil will stand much higher voltages than air before it will allow a spark to pass between the plates of the condenser. Oil also has much larger capacities than air. For these reasons the oil condensers are employed in transmitting stations where large quantities of energy are radiated at high potentials. Many air condensers are built in glass cases and can be converted into one of the oil type by filling the glass case with oil. This will increase the capacities of the condensers two or three times the value of the capacity which it has an air condenser. It should be noted, however, that oil condensers give rise to greater energy losses than those of the gaseous type.

For solidly built condensers of high capacity the prevalent practice is to employ solid dielectrics. For the same capacity they are very much smaller than air condensers and require no attention and no special care in handling. Of course, while in air condensers a discharge between plates leaves the condenser intact, a breakdown of the dielectric in "solid" condensers will badly damage, if not totally ruin, the condenser. Often the spark forms a carbon path between the plates, and carbon being a conductor of electricity, will prevent the accumulation of the charge on the plates. Further, solid dielectrics are apt to give rise to small but appreciable leakage currents, which will cause energy losses in the condenser.

Liquid condensers also share the quality of air condensers in being what may be called "self-repairing."

EXPERIMENTERS and amateurs, we want your ideas. Tell us about that new electrical stunt you have meant to write up right along, but never got to. Perhaps you have a new idea, perhaps you have seen some new electrically arranged "do-funny"—we want these ideas, all of them. For all such contributed articles that are accepted we will pay one cent a word upon publication. The shorter the article, and the better the illustration—whether it is a sketch or photograph—the better we like it. Why not get busy at once? Write legibly, in ink, and on one side of the paper only. EDITOR.

Potential

(516) Allen Croman, Fort Worth, Texas, inquires:

Q. 1. Are potential and energy the same?

A. 1 There is a considerable chance for misapprehension here. If a weight of ten pounds occupies a position 55 feet above a plane so that it is free to fall that distance, it possesses a potential energy of 550 foot-pounds, which is the energy of one horse-power-second. The potential in this case can be taken as 55 feet, so that it represents or is the measure of one-tenth of the potential energy of the weight in that position.

But if we had a unit quantity instead of the ten pounds, the potential or the height would be the measure of the energy potentially present in the weight or mass occupying so advantageous a position. Thus, if we take the unit of mass or weight as one pound, then one pound at a given height would represent foot-pounds of energy numerically equal to its height or the distance through which it is free to fall in units of feet. In other words, if our ten pounds were replaced by one pound, the energy would be equal to 55 foot-pounds, so that the height would give the numerical value of the energy. But the fact that potential may be equal to energy when acting on unit quantity does not make it the same thing.

There is another element of confusion in the terms mass and weight. Thus the energy of a mass in motion is equal to $\frac{1}{2}mv^2$. Sometimes in applying this formula, to determine, for instance, the kinetic energy of a moving projectile, mass and weight are taken as synonymous, and the foot-pounds thus calculated will be about 32 times too large. This is because mass is equal to weight divided by the acceleration of gravity. Mass is inherent in matter; weight as referred to our sphere is an accident in the sense, that it varies on different parts of the earth. A pound weighs less at the poles than at the equator, owing to difference in centrifugal force, and even to a slight extent to the different contour of the earth at those two points. Therefore, the weight of a body at different parts of the earth is affected by variations in gravitation and also by centrifugal force as it is usually called.

Our present unit of mass is the quantity of matter present in the gram; this is invariable, but the weight of the gram will vary at different latitudes. If one could buy a commodity at the equator, weighing it there, and could sell it for the same price per pound at one of the poles of the earth, he could get more for it.

Very absurd errors have been made by using the expression $\frac{1}{2}mv^2$ and treating mass and weight as the same.

Physical units (including electric units) are based on the standard units of mass (as above) of length (the centimeter) and the second, in other words, on standard units of mass, lineal space and time. From these three units what are called electrical units are derived, which in their practical form are termed the ohm, the volt, the henry, the farad, etc. Each one of these can appear as based in these three units, and can be expressed in terms of them, so that some can be expressed as centimeters, such as the unit of electrostatic capacity or the unit of electromagnetic self-inductance, and these units are used quite frequently, especially by foreign waters. Thus the unit of resistance reduces to length divided by time which is velocity.

In many foreign books the centimeter is used as the unit of inductance, and at one time it was often met with here. The unit of electrostatic capacity is often to be found expressed as the centimeter by German authors.

High Voltage Experiments

By Lester Reukema

(*Continued from page* 474)

natural frequency of the circuit formed by the coil (L_2) and the capacity (C_2) which is

$$f_2 \frac{1}{2 \times 3.1416 \sqrt{L_2 C_2}}$$

equals that of the primary circuit (f_1), then large oscillations of current will be set up in the secondary circuit, and these oscillations passing through the high inductance of coil (L_2) generate enormously high voltages. These high voltages, being impressed on the ball or other capacity (C_2), break down the surrounding air, causing the discharges of flame seen in the pictures. As soon as the energy of the primary circuit (L_1 C_1) has been handed over to the secondary circuit (L_2 C_2) the arc across the gap (S.G.) goes out, allowing the condenser (C_1) to again build up to the maximum voltage, when the cycle repeats itself.

What has taken several minutes to say occurs in less than a ten-thousandth of a second, since the natural frequency of each circuit is about 60,000 cycles per second. About five cycles are necessary to pass the energy from primary to secondary circuit. The frequencies f_1 and f_2 must be equal, which means that $L_1 \times C_1$ must equal $L_2 \times C_2$. Since the inductance L_2 is fixed, being determined by the dimensions and the number of turns of the large coil, and C_2 is fixed, being determined by the size of the ball or man used as a capacity and by its distance from surrounding objects, the frequencies are equalized by varying either L_1 or C_1. C_1 is varied by varying the number of milk bottles used, 144 bottles giving us best results. L_1 is varied by varying the number of turns used. When the frequencies are equal, the system is in resonance. The particular value of L_1 to use with any value of C_1 is easily determined by trial, merely shifting the movable connection on coil L_1 until a maximum discharge is obtained from the ball C_2.

According to the safety commission of California, one-tenth of an ampere of current passed through a man's body at ordinary frequencies will cause death. Yet, in our experiments, we pass enough current over and through the body from feet to hands to brilliantly light up several incandescent lights held in the hands. Since each wave train of energy lasts only about one five-thousandth of a second, to be followed by an interval of about one one-hundredth of a second before the next wave train comes along, at the beginning of each wave train about 200 amperes of current must be passing through the body, 2,000 times the amount which might kill at lower frequencies. Moreover, at commercial frequencies, anything over 1,000 volts is dangerous, and even voltages as low as 110 volts have killed persons many times. Yet we are impressing a million volts and more on a man's body without any danger. What causes the difference?

The higher the frequency, the less chance the current has to penetrate the conductor, whether that conductor be a copper wire or a human body. At 60,000 cycles, the frequency used in our experiments, practically all of the current passing through a half-inch wire is carried along the surface, only a negligible amount penetrating the wire more than one one-hundredth of an inch. This is the so-called "skin effect" of high frequency. In the same way the human body carries the current on the surface, the high frequency preventing any penetration farther in than the outer layers of the skin.

Certain precautions must be observed. Keep the body insulated, and far enough away from direct grounds to prevent power arcs to ground, which, though not dangerous, are unpleasant. Also remember that the circuit between the power transformer and the condenser (C_1) is carrying power at 60 cycles and at high voltage, so must not be touched; it is well not to touch any part of the primary circuit when the power is on. However, the energy in the secondary circuit is perfectly harmless.

Laboratory Reproduction of the Solvay Process

By Earle R. Caley, A. Sc.

(*Continued from page* 468)

Large clear crystals of sodium carbonate, which contain ten molecules of water of crystallization, are formed. These are removed from the disk and spread upon filter or blotting paper to dry. As soon as they are dry, which is shown by the edges turning white, they are placed in a tightly-stoppered dry bottle.

Experiment III

Preparation of Sodium Hydroxide or Caustic Soda

Sodium hydroxide or caustic soda is a powerful alkali used for a great variety of purposes in industrial chemistry. Common household lye is a form of caustic soda. This substance may be prepared from the sodium carbonate obtained in the last experiment.

A large beaker, provided with a stirring rod and mounted upon a stand over a Bunsen burner, as shown in Fig. IV, is all the apparatus needed. In addition a small amount of freshly-slaked lime is required. 200 grams of sodium carbonate are dissolved together in 200 c.c. of water in a beaker and 150 grams of slaked-lime added. The mixture is then boiled vigorously for several hours. From time to time a small quantity of the solution is removed and tested with a little dilute hydrochloric acid. Evolution of gas shows that some undecomposed carbonate still remains in solution.

As soon as a test shows that all the carbonate has been converted, the solution is filtered through the filtering arrangement shown in Fig. II. Solid calcium carbonate, which is formed and precipitated in the reaction, is left behind on the filter paper, while the solution containing the caustic soda runs through. This solution is then evaporated down (Fig. III) until the caustic alkali is obtained as a white solid cake. This may then be broken up and bottled.

Electric Property of Plants

By G. Kainz

(*Continued from page* 473)

leaves an excess of negative charge for the earth. This can be proved on the small scale by experiment.

We can, therefore, believe that the negative electricity of the earth or by far its greater part depends on the world of plant-life, and is due to atmospheric precipitation of rain. Hitherto the radio-active emanations from the surface of the earth were assumed to be necessary for explaining or accounting for the regeneration of the negative potential of the earth, but were found by most investigations in this line to be insufficient for the requirements of the case. Elster and Geitel, the most distinguished investigators, try to explain by the process of ion-absorption the negative charge, which, however, only can answer for a small part of the requirements. Linss regards the air as a conductor and believes that the negative charge is constantly departing from it, so that it would be completely discharged in two hours if there were not a continual addition of new charge thereto.

The peculiarity of many plants noted above stands in close relationship with electric cultivation, which will excite a much greater interest in Germany than before. I am firmly convinced that by this means our yield of crops can supply food quite independent of foreign sources, and the welfare of our people can be greatly increased thereby.

Chemical Vegetation

(*Continued from page* 479)

part, and the inner fluid of the seed is shot outward. But as soon as the inner fluid comes in contact with the outer solution a new membrane is precipitated about the protruded solution. This is repeated again and again, and this interesting process may be observed by carefully watching the upward growth of the plant through a reading glass. Then it will be seen that the growth is not regular and steady.

By slightly changing the entire procedure different growths will be obtained. A nutritive solution is prepared by making concentrated solutions of ordinary table salt in water and potassium ferrocyanide in water. Then make a 10 per cent. solution of gelatin in water. To each 10 ounces of pure water add one ounce of the 10 per cent. gelatine solution, one ounce of the saturated potassium ferrocyanide solution and one ounce of the saturated salt solution. Stir the mixture and warm slightly in hot water. When it is cold, add a seed made from one part of sugar and one part of copper sulphate, both these latter substances being powdered and mixed together. The seed is formed by adding a drop of water, stirring and kneading the resulting stiff paste in the fingers and forming a small ball half the size of a pea.

Be sure to heat the solution after it has stood for a day, so that the gelatine will set. Therefore the seed must be dropped into this nutritive solution after the heated liquid has cooled.

When seeds are used, made of sugar and cupric chloride in the same proportions, columnar growth will result which consists of innumerable tiny fine tubes closely grouped together; a distinct difference from those flat thalus plants produced by cupric chloride alone in a dilute solution of potassium ferro cyanide. In the same way characteristic growths are obtained if other salts are added to the nutritive solution such as potassium nitrate, ammonium nitrate, potassium iodide, etc.

A dilute solution of water glass in water also produces such chemical plants. Many salts can be used such as cobalt nitrate, nickel nitrate, ferric chloride, etc. When ferrous chloride is used as a seed and placed in a solution of water glass and water made by mixing these in equal proportions, a growth is obtained which resembles a combination of plants produced by nickel nitrate, cobalt nitrate and ferric chloride. Then, too, the ferrous chloride will produce peculiar microscopic organisms which resemble ciliated animals quite closely. They are produced almost instantaneously by first lightly sprinkling a little ferrous chloride dust upon a slide and covering the dust with a drop of the dilute water glass.

When the drop of water glass reaches the slide and the dust it contains, the ferrous chloride swells up into a tiny ball, larger dust particles elongating into snake-like tubes. This process is very rapid. Then the balls or elongations produce their cilia, and their growth is also rapid and, if closely observed, they can be seen to shoot out.

Later Batteries of the 19th Century

(*Continued from page* 456)

a sort of a couple or multitude of couples all over its surface interfering with the battery action. Smee's battery got rid of this in a great measure by the use of finely divided platinum on the electrode from whose "points" the hydrogen escaped. This was the second development. The third development was the chemical attack upon polarization when Grove employed nitric acid to oxidize the hydrogen. The objection to this was the nitric oxide gas given off, which took up oxygen from the air and gave most disagreeable fumes. The fourth development was the substitution of chromic acid or of one of its salts to replace nitric acid.. The chromic acid, anhydride, was reduced to the sesquioxide which dissolved in the sulphuric acid usually employed in this type of battery, so that absolutely no gas could be evolved.

Another development was the substitution of carbon for the platinum or silver electrode.

This early exhaustion of the battery at an early period was also overcome by the purely mechanical system of removing the plates from the battery when not in use, and depolarization was effected by keeping the plates in constant motion, or by blowing air through the battery.

The Ark of the Covenant

(*Continued from page* 451)

mans—on the qui vive. If London this week, why not Paris or Berlin the next?"

"Why not?" Lord Almeric agreed.

The Government Seems Inactive in the Face of the Robberies

"Br-r-r! And this damned government to move into action! Pah! Think of it, Pluscarden! The solemn idiots sitting all night through to this very morning debating a reduction of the Air Estimates—while this is happening, practically at the other end of the street! I wish to heaven the raiders had given *them* a whiff of the gas—the prosy, pusillanimous, pompous, pinheaded——"

It is hard to say how far Sir Thomas would have got with his alliteration if the telephone bell had not rung just then. Smiling at his friend, in spite of the gravity of the situation, Lord Almeric picked up the receiver.

"Yes," he said into the microphone, "Sir Thomas is here. Scotland Yard for you, Basildon."

"Ah, good!" said Sir Thomas. "We may have some news."

III

More Gasoline, or Petrol in the "English" Vocabulary, Has Been Taken. The Faces of Members in the House of Commons are Blackened

Sir Thomas Basildon took the receiver from Lord Almeric, and sat on the desk to talk into the instrument.

"Yes, Ferguson—Basildon speaking," he said. "Eh? Ah! Yes, well, I half expected that. Army and Navy Stores? Aha—that, too. Eh? Just a minute, Ferguson." He turned to us.

"The thing's complete. A petrol sation at Purfleet—the Anglo-American Oil Company—reports a deficiency of 6,000 litres of petrol, and the whole establishment put to sleep. The Army and Navy Stores in Victoria Street have been forced open, and a large quantity of foodstuffs taken away, money being left. Now, Ferguson——"

He turned to the mouthpiece again, and almost immediately an incredulous look passed over his face.

"No!" he shouted. "Don't pull your chief's leg, Ferguson—it isn't done! Tell me again. With their faces blackened? Well, I'm damned!"

He burst into a roar of laughter, shaking, shaking, until Lord Almeric and I sprang up in alarm. Soldiers have given way to hysterics in the midst of a great nervous strain before, and I thought the general had an attack. I don't know what Lord Almeric thought, but he evidently considered the laughter a little ill-timed.

"No, no! I'm all right, really—I'm not unstrung!" gasped Sir Thomas. "The raiders *did* gas the Commons this morning—and every man jack on the Treasury Bench woke up with his face blackened! Blackened, by George!—with burnt cork!"

"What?" cried Lord Almeric. "You aren't serious, Basildon?"

"Serious as cholera," said Sir Thomas. "Ferguson has just told me—and he's too solemn to joke on any subject."

There was no help for it. Lord Almeric tried hard to keep his face straight, but he couldn't—and presently he and the general were lying back helpless in chairs, laughing till tears streamed down their faces. I thought it funny enough, but their laughter got me more than the joke.

"Confound it, Basildon," said Lord Almeric,

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.

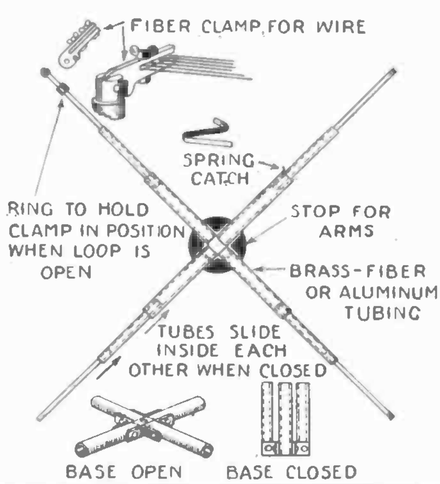
Crystal Detector

J. Clement, Orange, N. J., asks for advice on a crystal detector having a number of points touching the crystal.

A.—This crystal detector idea is very old and we doubt very much if you could secure a basic patent upon the same. As a matter of fact, if you will make a search of the Patent Office records you will find that a great many of these ideas have been covered, one as recently as September 16, 1924.

Portable Loop

Clyde D. Pace, Detroit, Mich., submits a drawing of a large portable loop with collapsible telescoping tube frame and asks our opinion of the device.



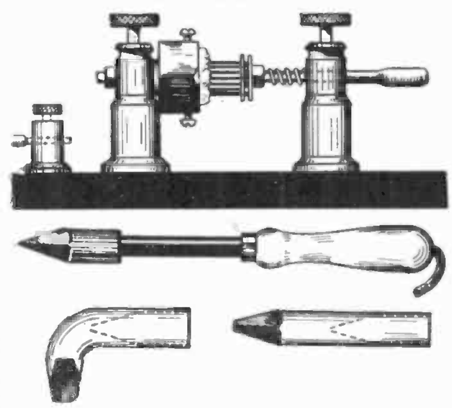
A.—Although the folding loop aerial which you have designed presents some pleasant features, it is not of very great value.

At the present time loops about 12 inches in diameter are being employed with great success at receiving stations, where the sets have one, two or three tubes, and use the reflex circuits. Big loops are not suitable for home use, and there seems to be no reason to use the collapsible type except for portable installations. Where large loops are required, they are generally rigidly constructed.

We do not believe that any firm would be interested in manufacturing your device.

Removable Tips for Soldering Irons

J. Bellingham, Philadelphia, Pa., asks whether we advise him to patent the idea of a soldering iron having removable tips for work on radio sets.



A.—We certainly would not suggest that you patent a removable tip soldering iron, because you will find it difficult to secure a worthwhile patent upon the idea. At the present time there are several soldering irons with removable tips selling for as little as $3.25, which price includes the iron and complete set of tips, cord and attachment plug. It is doubtful whether a patent, even if obtainable, upon an idea of this nature would protect the idea which you think is original with you.

Nevertheless, there is nothing to prevent you from placing an iron of this type on the market.

There is a great advantage in having different shaped tips for soldering irons, some crooked and some straight, especially for use on radio sets, and a certain demand might be looked for.

mopping his eyes. "The thing's farcical. It couldn't have been the raiders—surely not!"

"Must have been, Pluscarden. Boxes of radium were left beside the mace, addressed to some of our research institutions. The thing's conclusive!"

"It might have been one of the Opposition who woke up first and snatched the opportunity to make the front bench look ridiculous. It is enough to wreck the government."

"Might have been that," Sir Thomas chuckled, "and I hope it does wreck the government. We may get the Die-Hards back again, thank God."

"Let us hope so, Basildon. Well, there is little use in remaining here. We can do nothing until the clerks turn up, when we can go through the books. Heavens, what a mess!" said Lord Almeric. "I think a ride home and a bath, then early breakfast, is the idea. Let us go, Jimmy."

"Just let Mr. Boon show me those splashes of powdered glass, Pluscarden," Sir Thomas said, "and I'm with you. Could you drop me at Scotland Yard, if I send my car on? I want to talk to you on the way."

"Surely," said his lordship. "I'll pick you up outside."

There was no great crowd in the streets yet, for it was barely six o'clock, but Sir Thomas no sooner appeared than he was surrounded by newspaper men, who wanted a statement.

"I can't give you any statement yet," Sir Thomas protested. "Yes—yes, you can say I believe it to be the work of the *Parnassic* gang. That must be obvious. I shall issue a general statement when I get back to Scotland Yard. I must treat you all alike."

They fell away from him, but watched him from a distance, and when we had finished looking at the smears of glass and had gone on, I saw them gather round the spot and examine the powder closely.

"Glass bombs, I agree—probably containing the gas in liquid form," said Sir Thomas. "I wonder what it is?"

The newspaper men were still hanging around the smears when the three of us drove away in Lord Almeric's automobile.

"I must have those policemen sent away," said Sir Thomas, when we had passed through the cordon which was holding a small crowd back from the area which had been gassed. "It is nothing but a waste of time."

Recollections of Wartimes and Old Memories

He and Lord Almeric talked earnestly enough as we made our way to the West End, but though they did not exclude me from the conversation, it was of stuff that was Greek to me, and I was more interested in the wakening streets. I should like to have seen how Fleet Street was taking the event, but we went down a street which brought us out on the Embankment by Blackfriar's Bridge, passing the building that, during the war, was known as Adastral House, where I had tried to get into the British Flying Corps by swearing I was a British citizen. They wouldn't have me because of my age. I was only a kid, then. The building now seemed to be the offices of some commercial firm. I remembered my chagrin at being turned down by the British authorities, though they were extraordinarily kind to me, and looking back at that time, I got a-tingle all over to think that I was taking a lively part in an affair pretty nigh as exciting as the war I had wanted so much to get into.

It made me smile to think of the intense awe I should have had for the general in those days, or even for Lord Almeric, kind as he was. A mighty queer set of happenings, thought I, that brought me to be sitting in a limousine with the chief of the British C. I. D. and the deputy governor of the Bank of England!

We dropped Sir Thomas Basildon at New Scotland Yard, passing through the courtyard into Whitehall.

"You must permit me to worry you a trifle more, Mr. Boon," said Sir Thomas, as he stepped from the automobile. "I want you to recount your experiences to some of my men. May I ring you up at Lord Almeric's?—or, no—let us fix the time at twelve-thirty today. And perhaps I may be able to snatch a minute or two to see your new plane—what d'ye call it?—the *Merlin?*—if I may be allowed."

"Delighted, sir," said I. "Twelve-thirty, then. Here?"

"Here," he replied. "Ask for me at this door. They'll bring you straight up."

As we turned into Whitehall, I caught a glimpse of crowds in Parliament Square.

"Surely the Senate—the Parliament isn't still sitting?" I asked Lord Almeric.

"No," he smiled. "I expect they've gone home by now. But you know what crowds are. They will hang around Parliament Square for hours in the vain hope that they will see somebody who has had his face blackened, and they will give a circumstantial account of how nearly they accomplished it, years after."

IV

At Lord Almeric's House in Knightsbridge, Near Peter Pan's Haunts

We reached Lord Almeric's house in Knightsbridge about half-past six. Milliken was nowhere to be seen. I looked about for a servant, and found the one who had opened the door, yawning on the landing.

"Do you know where Mr. Milliken has gone?" I asked.

"No, sir. He must have slipped out early, before the 'ouse was properly astir, sir—if he has gone," said the man with an air of suspicion.

"Very well," said I.

I guessed that my mechanic had gone down to begin work on the *Merlin*, so I had a bath, and presently joined Lord Almeric at breakfast.

"What plans have you for today, Jimmy?" asked his lordship.

"First, I shall cable my father, and get him to begin the campaign against the raiders so that a cordon of scouts can be drawn around the coast tonight. Then I will have to attend to the *Merlin*. I propose starting for America at ten tomorrow, so as to arrive before dark."

"Bless me! How on earth can you do that?"

"I leave at ten from here, and take thirteen hours to make Long Island, nominally eleven o'clock at night—but as a matter of fact it will be six o'clock, American time, when I arrive. I get back the five hours we lost coming here."

"I had forgotten that," said Lord Almeric with a smile. "One of these days you young men will be beating time itself."

"Ah," said I. "We've got to fly at fourteen hundred and fifty kilometers per hour to beat time across the Atlantic from east to west."

Thirteen Hours From England to America

"Good God!" he cried. "You don't mean to say you've reckoned it out?"

"Why not?" I grinned at him. "When I started flying, ninety miles an hour was thought good going—that's a hundred and forty-four kilometers. My *Merlin* does three and a half times that speed, five hundred odd—which is more than a third of sun speed."

"Jimmy," said his lordship, "I give you up. You are too much for me. Tell Sir Thomas Basildon that when you see him today, will you."

"All right, sir."

He made for the door, where he turned.

"Good morning, Jimmy," said he. Then, "Do you think it will ever be done?"

"Why not? Shells do it. We might find a new principle of flight."

He went out, shaking his head.

I finished breakfast and went down to Battersea, where I found Milliken with half a dozen mechanics busy over the *Merlin*.

"Hullo, Milliken!" I said. "Where did you get to this morning?"

"Here," said he. "Knew that the sooner I got on the job, the better seeing that we'll be going back tomorrow. She's in fine trim, though—and as sound as a bell."

"Good. Did you have any breakfast?"

"There's a quick-breakfast counter and hot-dog cabin in the street on the other side of the bridge," said Milliken, "but they don't sell any fruit."

"'E means a cawrfee stall, sir," one of the mechanics explained.

"I get that."

"We're goin' to take 'im round the corner presently w'en we knocks off, to a chop-'ouse. 'E'll get a real breakfis' there. But 'e won't get no dog or fruit—'cept the sossidges might be dog—and a banana."

When the mechanics had gone, taking Milliken with them to the "chop-'ouse," I got off my coat and jacket and went over the bus. As Milliken had said, she was as sound as a bell. I worked with the men until midday, when I walked to Scotland Yard.

I told all I knew to a half dozen detectives, and stood the fire of questions they shot at me, until at last they all got up and trooped out, solemnly shaking hands with me, each one of them. Then Sir Thomas came along and inspected the *Merlin*. He expressed a high opinion of it and offered to use his influence if I wanted to dispose of it to the British Air Board. I told him that would depend on what the American authorities thought of it, and if they'd approve of Britain having it, my own country naturally coming first with me. He patted me on the shoulder at that, and said I was quite right. Then we had lunch together at his club, and after that I collected Milliken and pulled him around the town.

Crowds were collected here and there about the streets, and you'd come on small knots of people, laughing like mad over the papers. It did seem as if nobody cared a red cent about the raid on the banks, but that everybody thought a great deal of the joke played on the British ministers. I knew that many a minister and public servant had been sent into retirement through ridicule in France, and that the trait was peculiar to the French, but if the Cabinet of the British government could stand the guffaws that went up that afternoon, they were gummed to their seats with Hercules cement. I collected a few of the journals for future reference, and took Milliken to a picture theatre.

It was late again when we got back to Lord Almeric's, and we found his lordship waiting for us, with the whiskey decanter all ready. When at last we did go up to bed, he came into our rooms and pushed a tissue-wrapped package into my hand, and another into Milliken's. Then he went away before either of us could say anything.

I must say that Lord Almeric had speed in doing kindnesses. Milliken's package contained a

(Continued on page 499)

(Continued from page 496)

tobacco box of silver inside whose lid was engraved:

To W. M.
In remembrance of an enjoyable Atlantic flight with
"As proper a man as ever trod neat's leather,"
from A. P.

Mine was a gold cigarette-case, and in it was inscribed:

To J. V. B.
In remembrance of an Atlantic flight at
One-third of the sun's speed,
from A. P.

CHAPTER IX

I

The Raiding of Berlin and Paris

On the Sunday morning, Milliken went off early to the *Merlin*, taking his own luggage and mine. Lord Almeric and myself were having breakfast together, and had barely started when a servant came in with word that Sir Thomas Basildon wished to speak to his lordship on the phone. Lord Almeric came back with ever so slight a ruffle of excitement on his habitual calm.

"Basildon was right," he said. "He has just told me that the raiders visited both Berlin and Paris this morning."

"In one night!" I exclaimed. "Then it looks as if they have more than one airship in Europe, Lord Almeric. From Berlin to Paris is well over seven hundred kilometers, and the voyage would take the average airship more than four hours. Did he say at what time the raids took place?"

"No. He is on his way here now to say goodbye to you, Jimmy, and he will have breakfast with us. We shall have full details then." He turned to the butler. "Sir Thomas Basildon will have breakfast, Bunter."

"Very good, my lord."

"We are beginning to find the amazing measure of our mysterious enemy," Lord Almeric went on. "It must be a huge organization. Think of the quantities of ore which must have been reduced to result in all that radium—and the expense of the operation! Why, the amount left in New York, Louisville and London here represents as much money as has been taken in the various raids. That alone is a staggering fact. The preparations for these raids must have occupied a number of years."

"I'm with you there, Lord Almeric," said I, "and the secret has been astonishingly well kept. It beats me to know how the airships could have been built and their docking sheds erected without the connivance, or at least the hoodwinking, of the government in whichever country the bases of the raiders are situated. I said bases—because the thing gets bigger every bit of news. How can we be certain that there aren't a number of bases both in Europe and in America? I'm beginning to get fogged, Lord Almeric. When the thing first started, I thought we were up against an ordinary gang of crooks using new methods, and that one encounter with them in the *Merlin*, once she was carrying her armament, would settle the business. I'm not so sure now. I don't know where I'm going to begin."

"The problem is not at all a simple one," Lord Almeric agreed. "But you are taking the only way in which you personally can deal with the situation, Jimmy. If you can persuade your government to be fully prepared for further raids, you will do a great service. And you never know but that you will have the luck to encounter one or other of the airships in your seaplane. It will be an interesting fight if it ever occurs."

"There's the devil of it," I said. "My bus would have a better chance of whacking them than any other in existence—I may sound a bit chesty when I say that, but you know how good she is——"

"I think I do," he smiled, "and I don't think you the least 'chesty.'"

"Well, then. I sell my design to the government, and so give a number of good fellows a chance to pull off the fight I want to have myself. I'd like to be selfish and hog the whole thing for James V. Boon."

"Nonsense, Jimmy," said his lordship with a twinkle. "You'll play the game and give your side full benefit of your knowledge. You realize as well as anyone that only good team-work will scotch this menace."

"No. Hogging won't do," I agreed. "I'll have to put the *Merlin* into the pool."

In an incredibly short time we were joined by the chief of the C. I. D., who must have done violence to all the speed laws of the city.

"What do you think of it, Pluscarden?" he demanded. "Didn't I say Paris and Berlin, eh?"

Paris and Berlin Both Raided on the Same Morning—Details from Paris

"Yes, you were right, Basildon."

"An astonishing thing about it to me is both cities being attacked on the same morning," said Sir Thomas, already busy at the breakfast-table. "The raid on Berlin seems to have started at half-past twelve this morning. The district round the Reichsbank was subjected to gas at that time, while the Berliners were still on their pleasures. It was seen that something queer was happening. Folk venturing over a certain fairly definite line simply fell staggering to the ground, while others outside the line could watch it happen. The police tried to get into the district, but met with the same fate.

"It did not dawn on anyone," he went on, "anyone in authority, for some time, that the city was going through a similar experience as that of New York and London—even though I had warned the police yesterday morning—but at last gas-masks were sent for. They were no good against the anæsthetic. The police wearing them fell just the same. Would you oblige me with the mustard, Mr. Boon?"

"Did they try to get above the district in the air?" I asked, passing him the pot.

"Thanks," he said. "I'm coming to that. While they were still fiddling about with the masks and making bull-foolish rushes into the gassed area, nobody had thought of calling out the air scouts. They found the air clear on the tops of the buildings, and tried to approach that way, but of course came to openings that were impassable. It was over an hour before the first air scout came wheeling over the district—the damned fools—and by that time there was nothing to be seen above or below. About two o'clock it was possible to get into the area, though here and there the police were overcome by the gas even then. Pockets, I suppose, where the fumes—or whatever it is—had not dispersed. Only the Reichsbank had been forced. There was no gold to take, but not only had securities been destroyed, but the bulk of the ledgers had been absolutely obliterated by the use of acid. This is amazingly good ham, Pluscarden—your own breeding?"

"Good God!" said Lord Almeric. "Yes—the ham is from the farm."

"I've seldom tasted better," said Sir Thomas calmly. "Yes," he went on. "A pretty rotten trick! The usual boxes of radium had been left, this time in the bank itself. By one-thirty every available aeroplane was in the air, but though they may still be searching, up to now there has been neither sight nor sound of the raiders reported. That's Berlin. Now, here's a fact that will make you pause and consider, Mr. Boon. Within three hours, Paris was visited."

"One moment, Sir Thomas," I interrupted. "Three hours' actual flight—or clock time?"

"I mean three hours' actual flight," he replied. "I'm remembering the hour difference between Berlin and Paris clocks. Shortly after three, Paris time, the raiders had descended on that city. Here some considerable time passed before it was discovered that anything uncommon was in progress. The raid was concentrated on the Banque de France, and, if you remember your Paris, there's not much doing just there, even though the Avenue de l'Opéra close by may be swarming with night-birds. As soon as the alarm was given—pretty much from the same circumstances as had become apparent in Berlin—soldiers and gendarmerie were pushed along to surround the Banque, but they could not venture closer than the north side of the Place des Victoires on the north and on a line from the Palais Royal on the south. The police brought gas-masks, with the same result as in Berlin. They even brought up a wagonful of oxygen tubes, which they drove slowly up Rue des Bons Enfants, releasing the gas as they went. But the driver of the camion was overcome and switched off his engines before they were half-way up the street, and the crew was so affected that nothing could be seen of what was happening round the Banque. Meantime, there had been no delay in bringing up the air police, except for the time that had elapsed before the alarm was given. The airship was seen——"

"Ah!" cried Lord Almeric, and I felt a thrill run up my spine.

"It was seen," said Sir Thomas again. "It was snugged down on top of Rue Baillif, hugging close to the buildings. The unfortunate thing is that both the scouts who saw it developed engine trouble and had to come down. One almost crashed in the Palais Royal Gardens—he hit a plane tree—but the other made a good landing in the Place du Carrousel. By the time the others came up, the airship was gone, and although the French and we have been scouring the air, searchlights and everything, not a single trace of the airship has been discovered."

"What an unlucky thing that the engines of both machines conked," I said.

"If both pilots hadn't been men of proved daring and pluck," said Sir Thomas, "the inclination would be to say they funked, for when the engines were examined, not a thing wrong could be found. It's a mysterious affair. I can't make it out."

"Could the airship have done anything to them?" I asked.

"I don't see how she could," he replied. "They were flying high enough to clear the buildings in landing—and surely out of range of anything the raiders could do. What makes me mad is the selfishness, the pig-headedness of the German police. My people didn't get the news from Berlin until after the Paris call, and apparently the French only heard from Berlin while the raid on Paris was actually happening. If the Germans had been anything alive, and had sent warning to the French in time, the chances are that the airship would have been intercepted on approaching Paris. There's a rotten thing, if you like! The whole chance of getting at the raiders gone—and all because Gerry was too busy getting excited over his own affairs to think of anybody else!"

"You realize, of course, Sir Thomas," I said, "that if the same airship raided both Paris and Berlin, it must be up to doing close on three hundred kilometers an hour?"

"I hadn't lost sight of that, Mr. Boon," he replied, "and I don't know what to think. If it wasn't the same airship, we're left to the conclusion of at least two in Europe, which leads to the possibility that there may be one or two in America—and these raids are given the significance of a real war. What's the greatest airship speed made hitherto—can you remember?"

"Propert with his *America* did nearly two-twenty kilometers in an hour's spurt off Sandy Hook in 1926," I reminded him, "but a puff of wind buckled his machine. It was too light in construction."

"I remember. Phew! Three hundred is amazing speed for a dirigible—but—the brain that can discover a gas capable of putting cities to sleep—will you deny it the ability to invent a machine to do a mere three hundred kilometers the hour?"

Mystery of the Great Quantities of Radium

"Not me," said I. "It seems to me we're up against one of the cleverest minds of the century. Where did they—the raiders—get all that radium, for example? Lord Almeric was asking the question just before you arrived."

"Blessed if I know," said Sir Thomas, very much the bewildered soldier for a moment. "That radium would be enough to float a company in the city with millions of capital—eh, Pluscarden?"

"Yes, I should think so," said Lord Almeric. "But, Basildon—you haven't mentioned the damage that was done to the Banque de France——"

"Bless me," said Sir Thomas, helping himself to marmalade. "Didn't I tell you what happened there? They left radium as usual—and also gold ingots valued at twenty-five millions of francs——"

"What!" Lord Almeric jumped to his feet.

"They left gold valued at twenty-five million francs," Sir Thomas repeated quietly.

"What madness is this?" cried his lordship. "It is fantastic! Incredible!"

"I'm giving you the information that was passed to me, Pluscarden," Sir Thomas said distinctly.

"My dear fellow—I did not refer to you, but to this action of the raiders," Lord Almeric explained. "Tell me, did you learn if these ingots were stamped with any government mark?"

"I asked particularly about that. They bore no marks by which they could be identified."

"It is astonishing. I can find no real motive for any of the raids—but this—this—what do you make of it, Basildon?"

"I can make nothing of it—especially as the ledgers of the Banque de France suffered the same treatment as those of the Reichsbank—utterly obliterated."

"The thing seems to me so wanton—so useless," said Lord Almeric. "The trouble that must ensue—no record of transactions—how can all the complications that must result be sorted out? It is monstrous!"

"It's pretty damnable," Sir Thomas agreed, rising as he spoke. "If the idea of the raiders is to bring business to a standstill, they are going the right way about it. Well, we must do our best to run them to earth. Sitting still won't do any good. You'll do your best when you get back to America, Mr. Boon, to make those in authority realize the position? Your father will help you there."

"I shall cable Mr. Boon myself," said Lord Almeric, "and Jimmy here will supplement my efforts."

"That being so," said I, "the best thing I can do is to get back to America as quickly as I can. I can do nothing further on this side, Sir Thomas?"

"You have done us great service in bringing Lord Almeric back so speedily, and in telling us about the American raids," said he. "Your work is on the other side of the Atlantic. But I shall keep you posted. If any new development occurs of which the news might help you in your investigations, I shall inform you as quickly as I shall the police over there—depend on that. Now, I'll say good-bye—and wish you every possible good luck. I hope we shall meet again, Mr. Boon."

"I hope so, sir," I said. "Good-bye, and good luck to you, sir."

"Thanks. Good-bye. I shall see you later, Pluscarden?"

"Yes. I intend to see Jimmy off—then I shall be fully available, Basildon."

"Good."

Sir Thomas marched off, and presently Lord Almeric and I were driving down to Battersea and the *Merlin*.

We wasted no time in getting away. Lord Almeric bade Milliken and me hearty farewells, and to a cheer for my mechanic from his English confrères—with whom he had apparently established himself a favorite—we took off just before ten o'clock, due west and headed for our own country. With our luck holding, we reckoned to be at Gardiner Bay by half-past five American time.

II

The Start for America—the Descent at Gardiner's Bay, L. I.

We were flying high by the time we got above the Bristol Channel, and every now and then we would pass a plane, one of Sir Thomas Basildon's scouts. He must have sent out word of our departure, for we were not challenged. When we passed near enough, we invariably got a signal wishing us good luck, and once or twice a voice came over the radio phone, which was in open circuit, with a "Cheerio, *Merlin*—keep your eyes skinned going over!"

Once above the open sea, I gave the pilot seat to Milliken, and turned to read the English journals I had brought with me. They were full, of course, of the raid on the Bank of England, and for the most part the story was told without much flourish or waste of words. In the leading columns of some the fact was glossed over that the government had been caught napping with a policy of reducing the air service, and space was taken up with the useless condemnation of the "criminals" behind the raid. Those particular journals, it was easy to see, were government organs.

The papers of the opposite party vigorously rubbed in all the damaging facts, and were brightly humorous over the blackened faces of the Cabinet. One journal spoke ponderously of the affair in the House of Commons as if it had been a sort of nigger-minstrel show:

THE WESTMINSTER TROUPE OF MINSTRELS

There has long been a suspicion of a familiar flavor about the nightly entertainment at St. Stephen's Hall. Time and again some chord of memory has been struck, and we have endeavored in vain to trace where we had heard that note before, but the bright idea conceived by the leading comedian at our famous house of amusement—nothing more subtle than the use of a little burnt cork—revealed in a flash whence came the old familiar flavor. The Nigger Minstrels, of course!

"Brudder Bones, cane you tail me the simularrity between an orphan boy, the Prince of Wales, a bald-headed man, and a monkey's mother?"

"No, Brudder Jawnsun, ah cane not tail you the simularrity between—etc., etc."

The surprise sprung upon us was an elaborate one. It was known that great efforts were being made on the part of the management to provide a full-dress, bumper entertainment. None of the leading lights of the Front Bench were to be missing; from corner-man to corner-man, and from the front row to the back bench of the chorus, the full complement of the company was to be turned out for this occasion only. We were to witness the screaming absurdity entitled, "Too Much in the Air."

It must be confessed that the entertainment dragged a little at the start, due to the inclusion of too many stump speeches in the program.

The speakers, moreover, all were too conscientiously impersonating the old-time Members of Parliament, and it is a well-established axiom in the art of entertaining that close imitation of familiar types need not necessarily be funny. The broad touch of burlesque was needed. It is painful to report, so tedious did the show become, that not only the audience fell asleep, but the entertainers themselves were lulled into peaceful slumber! Even the bright particular stars of the Front Bench were affected, and fell victims to their own platitudes, sleeping a round couple of hours.

To be Continued

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