February

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# The EXPERIMENTER

## Electricity ~ Radio ~ Chemistry

Edited by HUGO GERNSBACK

**12 Pages of EXPERIMENTAL RADIO**

**FIRE UNDER WATER**

*See Page 216*

EXPERIMENTER PUBLISHING COMPANY, NEW YORK, PUBLISHERS OF
RADIO NEWS - SCIENCE & INVENTION - THE EXPERIMENTER - MOTOR CAMPER & TOURIST

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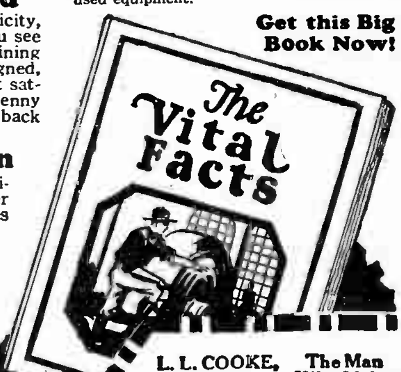


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# THE EXPERIMENTER READERS' BUREAU

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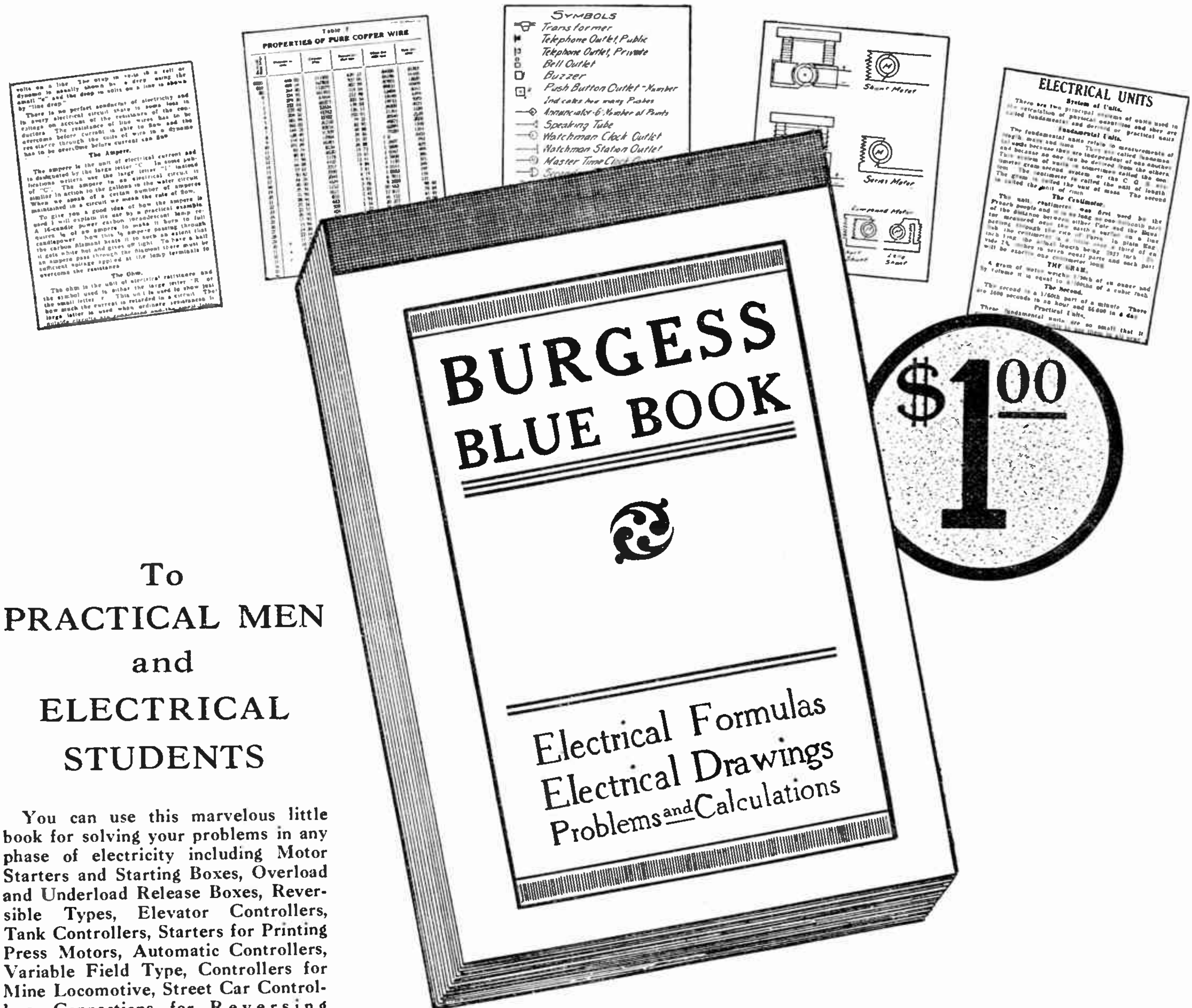


## To PRACTICAL MEN and ELECTRICAL STUDENTS

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If you are interested in calculation you can find plenty of it in the various work on Simple Electrical Mathematics, Electrical Units, Electrical Connections, Calculation of Unknown Resistances, Calculation of Current in Branches of Parallel Circuits, Calculation of Weight of Wire, Wire Gauge Rules, Ohm's Law, Watt's Law, Information regarding Wire used for Electrical Purposes, Wire Calculations, Wiring Calculations, Illumination Calculations, Shunt Instruments and Calculation of Resistance of Shunts, Power Calculations, Efficiency Calculations, Measuring of Unknown Resistances, Dynamo and Dynamo Troubles, Motors and Motor Troubles, Calculation of Size of Pulleys, Current Calculations in finding Impedance, Reactance, Inductance, Frequency, Speed of Alternators and Motors, Conductance, Susceptance, Admittance, Angle of Lag and Power Factor, and Formulas for use with Line Transformers.

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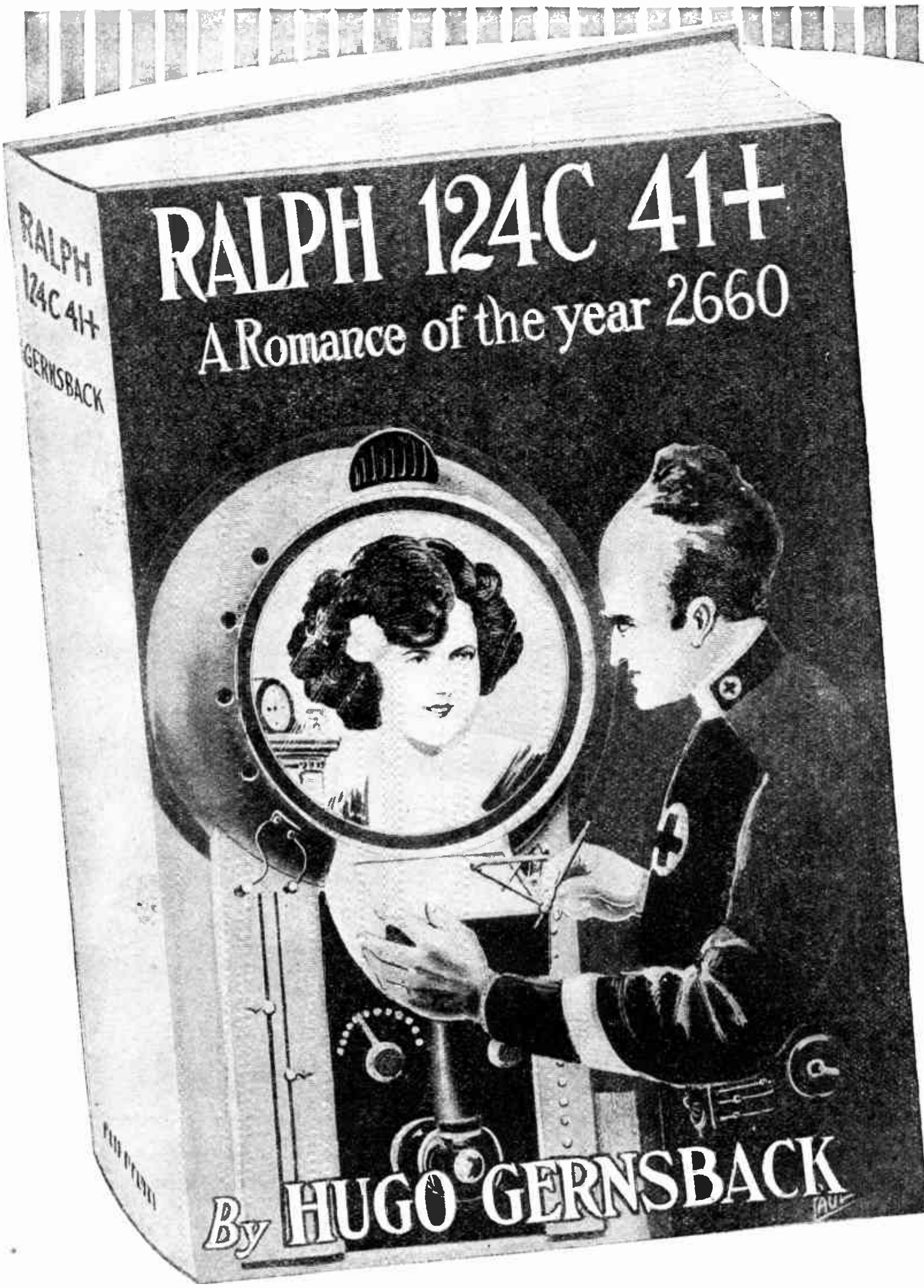


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# 700 YEARS HENCE

IN 1908, Mr. Hugo Gernsback, Editor of EXPERIMENTER, published the first radio magazine the world had ever seen—"Modern Electrics." In one of these volumes he ran a story entitled "Ralph 124C 41+ A Romance of the Year 2660." This story, although written many years ago, proved more valuable as the years went by, because many of the prophecies made in this book gradually came true.

This was in the days before broadcasting had even been thought of, and before we had the radio telephone, yet all of this is faithfully chronicled in this story.

Old-time readers of "Modern Electrics" probably remember the story, and now have a chance to get the complete book.

A pioneer in the electrical and radio field, Mr. Gernsback has a profound knowledge of the subjects, coupled with a finely trained and highly imaginative mind.

This unusual combination has enabled him to foreshadow with almost unbelievable accuracy some of the more recent developments. His earlier predictions, which have appeared from time to time during the past decade in many newspapers and magazines, are now realities. Every prophecy is based on accurate scientific knowledge. His ideas are no more fantastic than the realities and commonplaces of our everyday life would have been to our great grandfathers.

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Volume 5
No. 4

The EXPERIMENTER
Electricity ~ Radio ~ Chemistry

February
1926

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

# Announcement

WITH the present issue, THE EXPERIMENTER ceases to exist as a separate magazine. THE EXPERIMENTER will be merged with SCIENCE AND INVENTION, its sister magazine, beginning with the March issue.

The reason that prompted the publishers to take this step is that for the present, at least, there does not seem to be sufficient demand for a magazine of the experimental type to warrant the huge expense of publishing it.

When the magazine was first started in 1921, under the name of PRACTICAL ELECTRICS, the publishers hoped that it would be possible to sell at least 100,000 copies. These hopes were not realized. Subsequently, in November, 1924, the magazine was changed to THE EXPERIMENTER, and although an advertising campaign was put on and a large sum of money was spent to popularize the magazine, and although 100,000 copies were printed for quite a while, it was impossible to sell this number of copies, and the magazine could not make sufficient progress to warrant continuing its publication.

Our readers appreciate the fact that no magazine can live unless it has a good following among its advertisers. While THE EXPERIMENTER enjoyed some excellent advertising patronage, there was, at no time, a sufficient amount to warrant the expense of publishing the magazine. The magazine steadily lost money, and the prospects for the present do not seem likely that the publishers can interest a sufficiently large section of the public to warrant a further outlay of money.

Under the circumstances, the only thing to do is to merge THE EXPERIMENTER with SCIENCE AND INVENTION, which the publishers are doing, beginning with the March issue, as already explained. All the best features of THE EXPERIMENTER are being retained in our magazine SCIENCE AND INVENTION, which will take over the following departments:

*Junior Experimenter,*
*Experimental Electrics,*
*Experimental Chemistry.*

These departments were proven by popular vote to be the most popular among readers of THE EXPERIMENTER, and will be continued in SCIENCE AND INVENTION just as they ran in THE EXPERIMENTER.

Inasmuch as SCIENCE AND INVENTION already contains a number of departments which are practically the same as those in THE EXPERIMENTER, it is felt that the readers of THE EXPERIMENTER will gain much in becoming permanent readers of SCIENCE AND INVENTION. The departments referred to, which have been run right along in SCIENCE AND INVENTION, include a great many articles on Chemistry, "The Constructor," "How to Make It," "Wrinkles," "Recipes and Formulas," a popular radio section, "The Radio Oracle," "The Latest Patents," and "The Oracle."

To our subscribers of THE EXPERIMENTER magazine we wish to announce that the remainder of their subscriptions will be filled by subscriptions to SCIENCE AND INVENTION magazine.

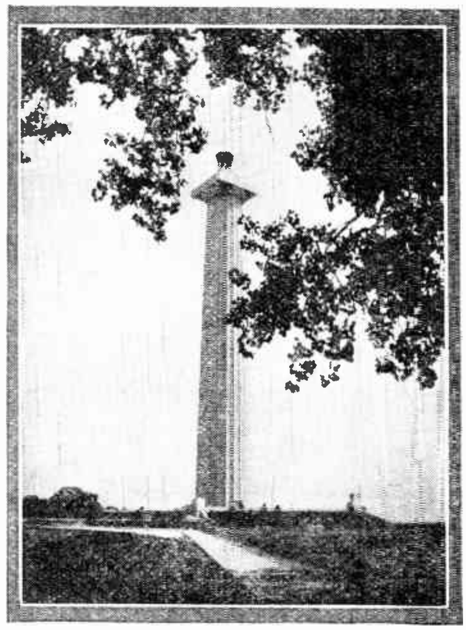
—THE PUBLISHERS.

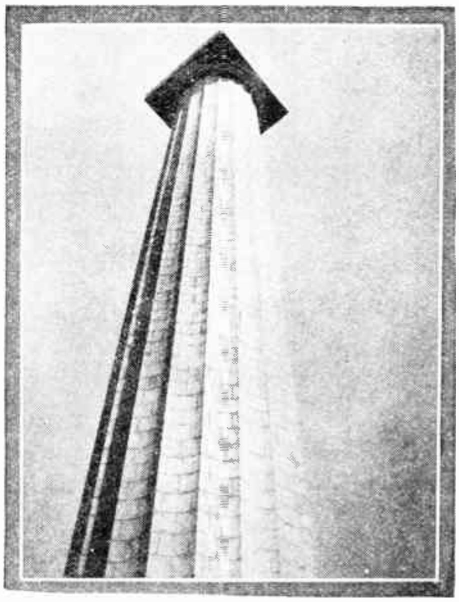
Mr. Hugo Gernsback speaks every Monday at 9 P. M. from Station WRNY on various scientific and radio subjects.

# Curious Lightning Rod on Perry Monument

By FELIX J. KOCH

We give three views of the great Perry Monument on the shores of Lake Erie, commemorating Perry's victory in the War of 1812. On the left is seen a bar of Monel metal, which forms the terminal of the lightning rod. Two other views of the monument are given; its height exceeds that of the Bunker Hill Monument by over 100 feet. It has proved a great attraction for tourists.





WHILE the sightseeing world at large has rather neglected Putin Bay, on Lake Erie, for tourist pilgrimage, folk of the larger lake cities *do* come on excursions, the pleasant months over, and this at the rate of 1,417 visitors to the Perry Memorial in a single day.

This Perry Monument is, of course, the one thing most of all the stranger to the place has to see—and so he tours it, base to top.

To save the caller the long climb to the parapet, elevator service has been installed, and this stands unique among the famous elevators of the world, operating, technically speaking, "upside-down." For reasons of adaptability, most all the machinery driving this "lift," as foreign callers term it, is located at the summit of the shaft.

Emerging from the elevator, 329 feet above Lake Erie, one steps from a small alcove-chamber to a huge parapet, for enjoying the exquisite view.

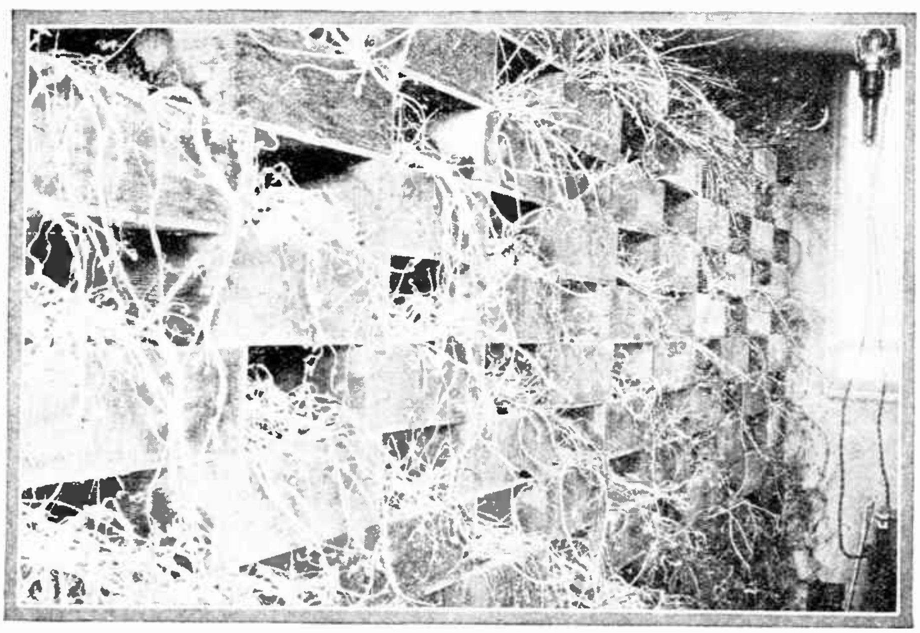
Along the top of the stone coping to the belvidere, perhaps two inches from the edge, there is a rail of a metal close akin to iron itself (monel metal). This rail, or band, on its side, like an ornamental strip across the stone, pure and simple, is top element of the lightning "rod"; presumed sufficient to serve the greater part of the monument. The Perry Monument Commission has found it well worth its while installing such a unique precaution against lightning here, as a result of experiences all its own.

Lightning once struck the monument; shattering an entire corner away. Stonecutters had to be brought from Cleveland, as the nearest source of supply for men skilled to do work of the kind. It required several days for the task.

Again—strange freak of nature—the lightning one day struck a stated point on the tower, knocked three stones from their places, but bothered nothing else.

There have been other attacks of lightning here, again and again. As a result, the commission, believing prudence less expensive than valor, turned to making the proverbial stitch in time, and so has installed about the edge of the big parapet, which it bounds, the ornamental and most protective bit of rail shown in the accompanying photograph.

# Electric Bug House

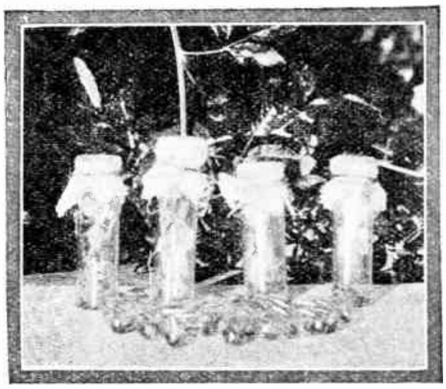


To exterminate the mealy-bug, a destructive insect troubling the grape growers of California, the popularly termed lady-bug is being propagated, and to feed it the obnoxious mealy-bug is raised in the insectary, which we illustrate. Above are seen potato shoots on which the mealy-bugs live, so as to nourish and support their natural enemy, the lady-bug.

THE San Joaquin County Insectary, Lodi, Calif., is the first insectary to use electric heat. The practice hitherto has been to use gas or other fuels, with manual temperature control.

This insectary is engaged in research work to determine the possibilities of using the beetle-bug, the so-called lady-bug, to rid vineyards of the mealy-bug, a pest which is causing much loss. This mealy-bug is a small insect which multiplies very rapidly and which thrives on the juices of the young and tender grapevine shoots. The female grows about four or five times larger than the male, which she outlives. The bugs are very destructive to the grapevines, as the fluid substance deposited by them on the tender shoots causes mildew and a discoloration of the grapes, besides furnishing food for fungus growth.

Beetle-bugs, however, live and thrive solely on mealy-bugs. Thus, in the process of raising them, it is first necessary to raise mealy-bugs to feed and fatten them. For this purpose, potatoes are planted in small trays filled with a few inches of soil. Each room contains sufficient trays of potatoes to plant the equivalent of an acre. The rooms are kept dark and at a constant temperature of 65° F. until the potatoes have



**Bottles containing different varieties of lady-bugs; capsules lying on the table in front of the bottles contain five bugs each, raised in the insectary.**

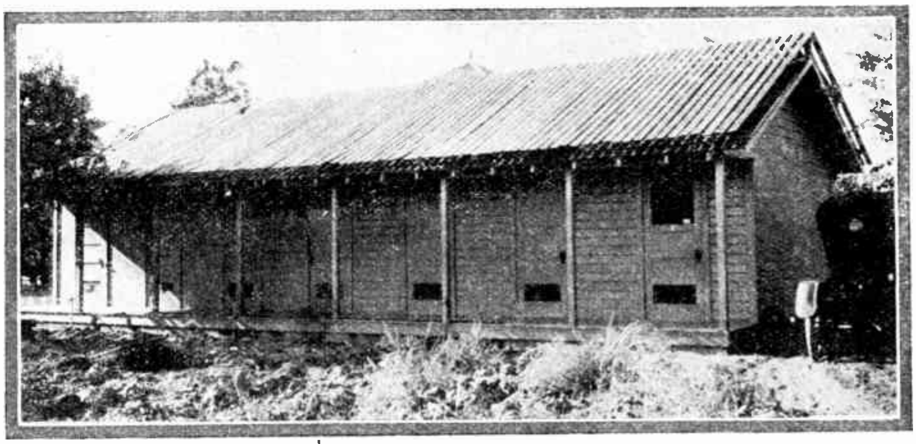
sprouted and developed long shoots. The purpose of a dark room is to cause the sprouts to grow long and spongy with a minimum of leaves.

After the sprouts have developed, a few mealy-bugs are planted on them. The temperature from then on is maintained constant at 80° F., causing the mealy-bugs to multiply very rapidly, each hatch producing about 600 eggs, which hatch into bugs in about a month. After the mealy-bugs have developed, beetle-bugs are placed on the sprouts to feed on them.

At present, three different species of beetle-bugs are being propagated; one is imported from Australia and the other two are produced in California. The beetle-bugs eat nothing but the mealy-bugs. They lay and hatch about 250 eggs at one time, the first hatch taking place in about twelve days, the insect being in the form of an immature worm or larva. The larva then develops into the adult stage. Before the stage of pupation, or transformation, the beetle-bugs crawl from the sprouts to sacks placed immediately behind the trays.

At this stage of the development, light is admitted and the insects develop wings, then seek the light and collect on the windows. They are then gathered from the windows and placed on the infected grapevines, about twelve to each vine, the number varying according to the amount of infection.

The San Joaquin County Insectary has four rooms, each approximately twelve feet long, six feet wide and eight feet high. In each room is installed an Edison Electric Appliance 2,000-kilowatt heater. Temperature is regulated by a CR-2990 thermostat and CR-7002 contactor, both General Electric manufacture.



**General exterior view of the insectary. Notice the double roof, designed to keep the interior cool.**

# Power of the Earth's Lightning

**An impressive photograph of a lightning discharge. This is an unusually beautiful display and in the article below the power of the lightning of the entire earth, such as exhibited in the two photographs on this page, is approximately calculated by F. W. Peck, Jr., who has acquired great fame as an investigator of high potential discharges.**

THE electric energy now produced at Niagara Falls is less than that produced by nature in the thunder storms always in progress throughout the world, was calculated thus by F. W. Peek, Jr., consulting engineer of the Pittsfield Works of the General Electric Company, in speaking before a joint meeting of the Detroit and Ann Arbor sections of the American Institute of Electrical Engineers at Ann Arbor on Tuesday night, May 26. The lecture, "Lightning and Other High Voltage Phenomena," described the interesting work which is being done in the Pittsfield, Mass., laboratory with artificial lightning generators.

Statistics show that at any instant there is an average of 1800 thunder storms in progress in the world, giving 300,000 lightning flashes per hour. Investigations with laboratory lightning show that the energy of a severe lightning flash is about four kilowatt-hours. The total energy represented by 300,000 severe flashes or one hour of the world's lightning would therefore be 1,200,000 kilowatt-hours, or more than 1,500,000 horsepower operating continuously hour after hour for year after year.

The developed capacity of Niagara Falls is about 1,000,000 horsepower. Six million horsepower could be produced there, however, if all of the available energy were used.

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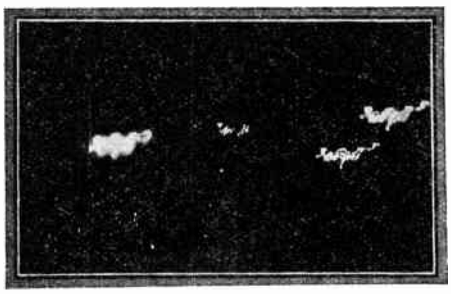
FROM one of our readers we have received the interesting photographs reproduced here. This description follows:

Enclosed please find an untouched photograph taken during a recent electrical storm. The unusual feature of this photo is the peculiar formation of the lightning flashes.



**A very peculiar photograph which has been untouched shows views of a lightning discharge; some of the discharges when closely looked at present the appearance of a sort of writing on the sky.**

The vertical shaft noted at the right is the aerial pole on the home of my brother-in-law. Although there seems to be some discharge from the clouds in the direction of the pole, lightning did not strike his house.

Some of the flash streaks look like writing in the sky, and this is one of the most unusual pictures taken of a lightning flash that I have ever seen.

*Contributed by Dan C. Wilkerson.*

# Electrical Horse-Riding

A GREAT deal of attention has been given recently to an electric iron horse which is used as a means of exercise. The attention was due to the fact that it has been used by the President of the United States. Our illustration shows it in use by a lady who adopts the side-saddle position.

The general idea is given clearly by the photograph. It is enough to say that, by intermittent motions, the gait of a horse is more or less accurately reproduced. A fact known to all horsemen is that horses vary in their individual gaits, and sometimes it is quite a problem for a rider to catch the motion of a horse enough to adapt himself to it.

The fatigue in riding is increased and the pleasure greatly diminished if one is not able to catch the particular motions of a horse.

**The iron horse operated by electricity, designed to give exercise for the rider. It is this animal that is ridden by President Coolidge.**

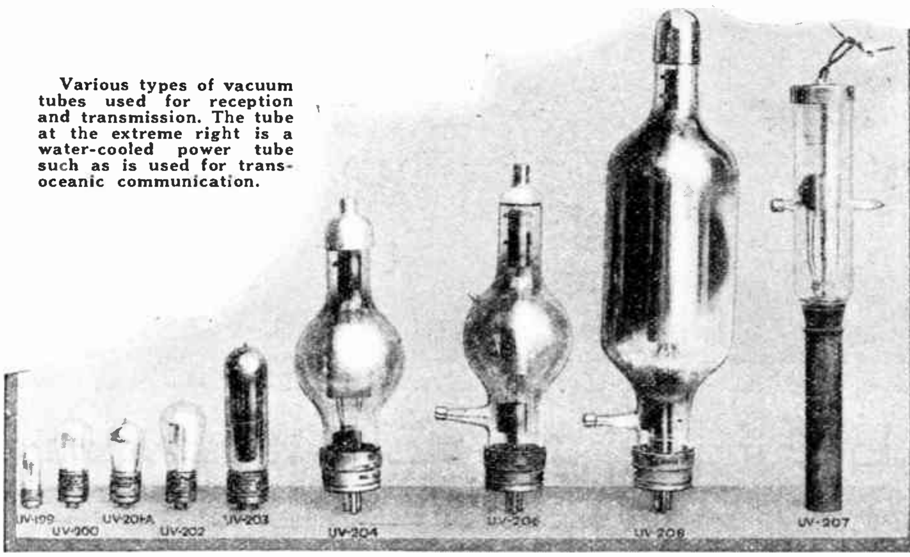
# EXPERIMENTAL RADIO

CONDUCTED BY LEON L. ADELMAN

# The Evolution of the Vacuum Tube

PART 3

By Leon L. Adelman, A.M., I.R.E.




Various types of vacuum tubes used for reception and transmission. The tube at the extreme right is a water-cooled power tube such as is used for transoceanic communication.

THE invention of the three-element vacuum tube, in itself the greatest marvel of the electrical and radio field, and its tremendous improvement through constant research and development, have made possible the highly efficient broadcast transmission and reception of today.

Primarily, the radio tube functions from the ability of the filament to emit electrons and thereby produce a condition of electrical conduction between it and the plate. This stream of electrons is referred to as the plate current and is regulated by the interposition of the grid. The ratio between the energy consumed by the filament and the amount of plate current or emission, constitutes a measure of the relative efficiency of the tube.

The tendency, therefore, is to produce a tube having the greatest electronic emission with a low current consumption. We shall review the advance in filament design and structure and point out wherein it is the most important factor in the life of a tube.

The first electric lamps had carbon filaments; Edison had found them to be the most successful at that time. DeForest used them, but was confronted with the problem of "burn-out." He then incorporated two filaments in his tubes, but not until the advent of tungsten in the electric field was any measurable success achieved.

Many will, no doubt, recall the "ancient" Marconi-Morehead tubes which operated with a filament consumption of more than six watts (one ampere at six volts). Those were the days when one had to be careful when buying tubes, so that they would be suitable for use either as detector or amplifier, but seldom for both purposes. One had to ask for a "soft" tube if he desired a detector, or a "hard" tube if an amplifier. The gaseous content of the tube was the determining factor for its use as detector or amplifier, and since the methods for exhausting tubes at that date had not advanced to a state of perfection where uniformity existed, many poor tubes were the result. A "soft" tube had a higher gas content than a "hard" one.

Then came the oxide coated platinum filaments, used extensively in the so-called "E" and "J" tubes. These were the VT1's and 2's which found wide use and which had much greater longevity and far better characteristics.

In the present-day tubes, we have the thoriated tungsten filaments, a decided improvement, the filament consumption being 1.25 watts (¼ ampere at 5 volts).

Of course, besides the filament, there are the grid and the plate. Edison was the first to place a plate in the vicinity of the filament. He employed it between the legs of the filament and later Fleming modified this and introduced the cylindrical plate. Copper and nickel were used, and now tungsten, the latter metal being adopted because of its ability to withstand heat. As for the grid, DeForest first used a short piece of wire in zig-zag shape. This was changed into a small spiral and then finally evolved into the form used at present—a flattened spiral helix of nickel wire.

The mechanical design and spacing of the electrodes determine only the operating characteristics of the tube, whereas its efficiency depends solely on the ability of the filament, which is the cathode, to emit electrons.

The average vacuum tube, such as of the —01A type, will operate either as detector or amplifier very satisfactorily, merely by giving it the proper plate voltage. But whether the tube will function as either detector or amplifier, is no indication of its efficiency. We therefore come to what is known as the characteristics of the tube.

The average tube, such as we use in our receivers, is rated as follows:

| | |
|---|---|
| Filament terminal, volts | 5.0 |
| Filament current, amperes | 0.25 |
| "B" battery volts (detector) | 22.5 to 45. |
| "B" battery volts (amplifier) | 90.0 to 135. |
| Plate current | 3 to 4 mils |
| Output resistance | 12,000 to 11,000 ohms |
| Mutual conductance | 675 to 725 micromhos |
| Voltage amplification factor | 8 |

It will be noted that the filament terminal voltage is 5 volts, at which potential .25 ampere flows through the filament. The resistance of the filament rheostat, according to Ohm's law, need be only 4 ohms to take care of the voltage drop. This consideration comes as a result of using a 6-volt storage battery as the source of filament supply. Six ohm rheostats are thus sufficient for all practical purposes.

For reasons that exist because of an allowed variable plate voltage and due to the use of technical terms as yet unexplained, the following details should be carefully studied.

These symbols should be memorized:

$E_f$ = Filament voltage.
$I_f$ = Filament current.
$E_p$ = Plate voltage.
$I_p$ = Plate current.
$E_g$ = Grid voltage.
Σ = Impedance.
μ = Amplification constant.
$G_m$ = Mutual conductance.

Let us now consider Fig. 1. Here it will be seen that a plate battery, or the "B" battery, has been connected in circuit with a tube, the grid being left free. We shall see how the plate or space current varies with the potential supplied to the filament. Assuming a voltage of 90, the average used for an amplifier tube, reference to the graph shows that the space current increases only slowly at first and then more rapidly, when finally—the filament voltage having been adjusted to normal—the plate current remains practically constant, indicating a condition

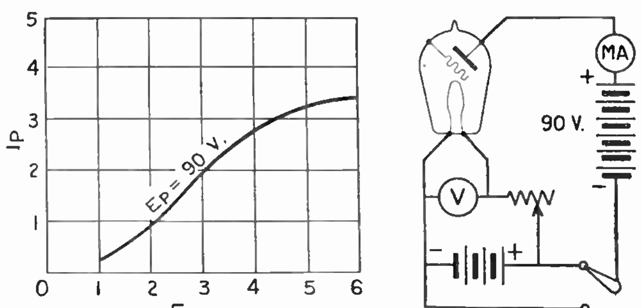



FIG. 1

No appreciable emission from the filament is obtained until the normal voltage of five volts is applied to it. Diagram shows the apparatus with which the curve was obtained.

of saturation. This condition can be explained by the reason that, with the given 90 volts on the plate, a certain maximum number of electrons per unit of time can be attracted to it, and since the filament can supply little or no more, having been adjusted to normal operating conditions, the space current becomes constant in value.

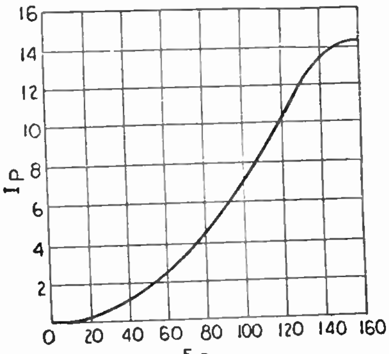
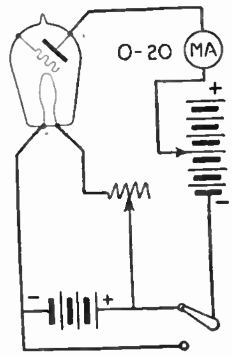



FIG. 2




**The plate current is a function of the plate voltage, the accompanying curve showing how the current varies with the applied potential. The average receiving tube is made for operation with 90 volts of "B" battery. At this potential, it can be seen that the plate current is approximately five milliamperes.**

It thus appears evident that the potential applied to the plate has something to do with the amount of space current obtainable. Fig. 2 shows this relation. The filament is operated at the specified 5 volts and a "B" battery of 100 volts or more is connected in series with a milliammeter and the plate of the tube. By gradually increasing the plate voltage in steps of 10 volts or so, and recording the readings of the milliammeter, a graph similar to the one shown will result. Note how the plate current increases up to a certain value and then becomes constant—evidence of a condition of saturation: the plate now attracts to itself all the available electrons thrown off by the filament.

In both Figs. 1 and 2, the negative terminal of the "B" battery can either be connected to the negative or positive terminal of the "A" battery, the only difference being in the slightly increased readings of the milliammeter when the positive "A" is connected to the negative "B." The voltage of the "A" battery is thus added to that of the "B."

Thus far, we have not been concerned with the connection of the grid. It is imperative that we now take it into consideration.

In Fig. 3 will be seen a graph depicting how the plate current varies with the grid potential. Keeping in mind the fact that a positively charged grid will aid the flow of electrons from the filament and will, when negatively charged, repel electrons or even completely stop the current flow, it is interesting to see to what extent the phenomenon takes place. Curves *a*, *b* and *c* show the effect of grid-bias, as it is called, upon the space current, as obtained from "B" batteries of 90, 45 and 22½ volts.

It can, therefore, be understood that the plate current is a function of or varies with the filament voltage, grid potential and plate potential.

In normal operation, however, the filament and plate potentials are kept constant and the only variable is the grid potential which is supplied by the radio frequency waves and varies with their modulations. As stated before, whether the tube will act as a detector or as an amplifier was due to the amount of plate potential used. Let us see how it controls the rectifying and amplifying properties of the tube.

It has been pointed out that the tube is conductive in one direction only and that the current in the plate circuit of the tube is always direct, but may vary in intensity at either audio or radio frequency, depending upon the purpose for which it is used.

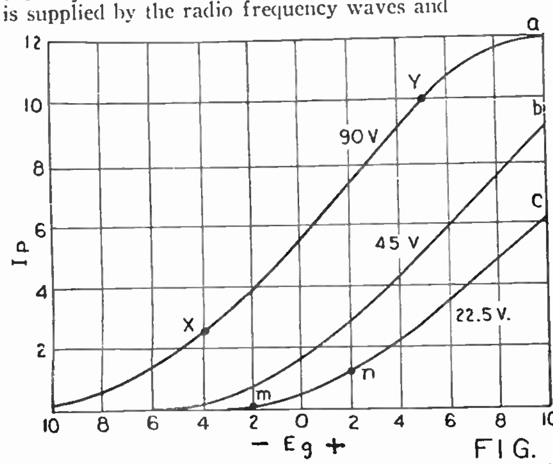
Reference to Fig. 3 will show that the curves in the order of their steepness, *i.e.*, affording the greatest plate current variation for a given grid potential change, are 90-volt, 45-volt and lastly 22½-volt. In the 90-volt graph, it will be noted that between the points *x* and *y*, designating equal negative and positive grid voltages, equal variations both above and below the normal plate current are effected. The use of 90 volts for straight amplification purposes would, therefore, appear very effective, since the alternating potentials on the grid would be reproduced in the plate circuit with fidelity; equal amplification of both positive and negative cycles being obtainable. In Fig. 4 is shown how the plate current varies with respect to a complete cycle on the grid.

For rectification or detection, the 22½-volt curve will be found best, for here equal positive and negative grid charges cause unequal plate current variations; the positive half of the cycle causes an increase in plate current greater than the decrease caused by the negative half-cycle, at the lower bend of the curve. Similarly, the positive half-cycle causes an increase in plate current less than the decrease caused by the negative half-cycle, at the upper bend of the curve. Fig. 5 may be consulted for graphical explanation. The lower bend of the characteristic is the best point on which to operate, since to allow the grid to become positive would mean that a potential difference would exist between it and the filament and thus a grid current would be set up which would interfere with the true operation of the tube.

This, then, briefly explains the action of the tube as an amplifier and as a detector. An explanation of the various terms having to do with the vacuum tube follows:

*Amplification Constant.* The amplification constant of a tube is a factor that expresses the maximum voltage amplification it is possible to obtain. It is defined as the ratio of change in the plate voltage necessary to change the plate current a given amount, to the change of grid voltage which will produce the same variation in the plate current. In other words, if a change of *x* volts plate potential produces a change of *y* mils in the plate current, then it will take *z* volts grid potential to effect the same change in plate current. The relation becomes

$$\mu = \frac{Ip}{Eg} \times \frac{Ep}{Ip} \text{ and } \therefore \mu = \frac{Ep\ (\text{change})}{Eg\ (\text{change})}.$$



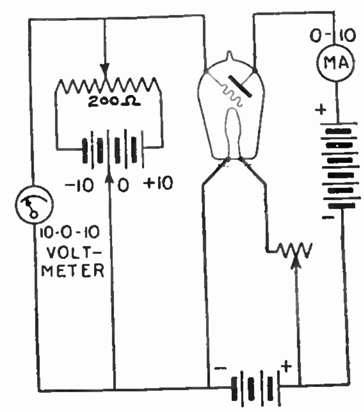
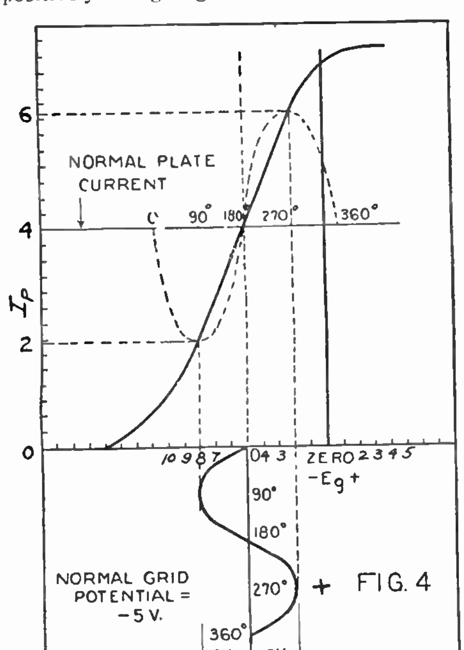




FIG. 3

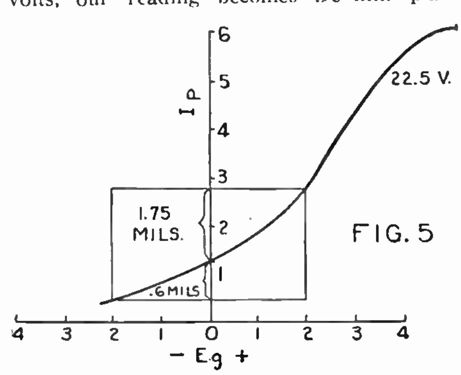
**Characteristic curves as obtained by the apparatus above. Note how much greater "straight-line amplification" can be obtained by using higher voltages.**




**In normal operation, the grid is negatively biased at five volts. How the plate current varies with the grid potential is graphically depicted above.**

If we consider the curve of Fig. 6, we shall note that with a plate voltage of 45, we obtain 1.60 mils of plate current, at 0 grid potential and normal filament current. Then, again, if we lower the plate voltage to 35 volts, our reading becomes .95 mil. plate current. This means, therefore, that a decrease of 10 volts plate potential has caused a .65 mil. decrease in plate current. According to the graph, it would require a negative grid potential of 1.25 volts to produce a similar decrease in plate current. It thus

(*Continued on page* 241)




**Curve showing the "detector action" of the vacuum tube. Note that equal grid potentials of opposite polarity cause unequal plate current fluctuations.**

# The Electron

## By Dr. PETER I. WOLD*—PART II

Niels Bohr, the illustrious Norwegian scientist, who has done considerable research on the theory of atomic structures.

### THIRD LECTURE

#### Effect of Electron Discovery on Scientific Theories

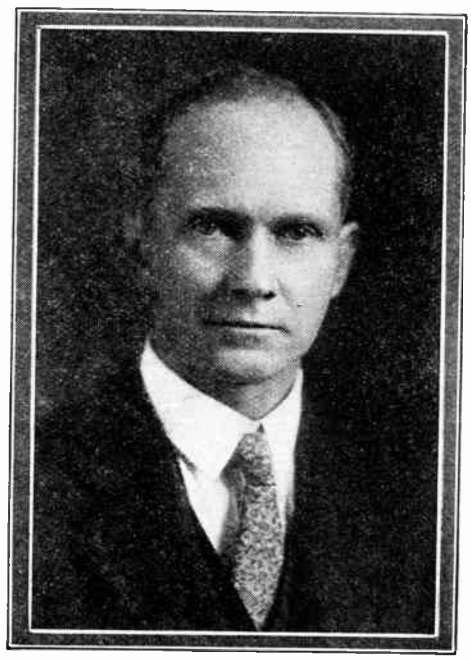
SO FAR, I have described the discovery of the electron by J. J. Thomson, and have spoken of its mass, size and charge. The conclusion was unavoidable that atoms are complex particles which can be subdivided and broken up. Further studies have shown that each atom consists of a positive portion and some negative electrons. The present, most acceptable theory is that each atom consists of a positive nucleus which is different for every kind of atom and that this nucleus is surrounded by electrons which are the same individually for all atoms but varying in number, the number for each atom being enough, normally, so that their combined negative charges are just equal to the positive charge of the nucleus and they are then electrically neutral. It was to be expected that so new and radical a conception as this should have a profound effect on the work and ideas of chemists. This is so true that our theories in chemistry have had to be largely made over, and much recent work is based on the study of the structure of the atom. The applications of the new ideas to chemistry will be taken up by my colleague, Dr. Ellery, of the Chemistry Department of Union College, in another article.

Physics has also been very much affected, and I now wish to take up the explanations which we now give for certain phenomena which formerly puzzled scientists exceedingly. Take, for example, lightning, or take electric discharge through tubes containing gases at low pressures. Many of you have, no doubt, seen in the latter the beautifully colored effects, sometimes blue, sometimes red or green and changing not only in color, but in form as changes in pressure and in gas take place. These phenomena had formerly received no satisfactory explanation, but now, while they are still complex, many have been worked out in detail and we have a general understanding of all of them. Briefly, the explanation is as follows:

It is found that in any gases there are always a few atoms which have lost a negatively charged electron, leaving a positively charged particle or ion. This is called natural ionization. Ordinarily, these will wander around, and, in due course, recombine; but, if in this gas we should place two metal bodies, one charged positively and one negatively, the negative electrons will travel towards the positive body and the positive ions will travel in the other direction. As such, they will constitute an electric current, although a very small one. These ions have numerous collisions and therefore have difficulty in getting up to high velocity. If we make the electric field between the metal bodies or electrodes strong enough, the particles may acquire sufficient velocity so that when they collide with an atom, they will knock off an electron and several ions may be produced, each of which would join in the stream. These would also have collisions and produce further ions and as a result the current would build up to large values in a very short time—and we have a disruptive discharge such as in lightning. It is not able to maintain itself, however, and very soon stops. That is the present day explanation of this familiar phenomenon.

There is another way to increase the velocity of ions, and that is to remove much of the gas in the tube which is being used. This means that the gas atoms are farther apart and so the natural ions travel farther between collisions and have a chance to reach higher velocities. If enough gas is removed, they will acquire sufficient velocity so that electrons again are knocked off the neutral atoms and the current builds up. In this case we find, however, that with moderate voltages the discharge will maintain itself continuously and quietly.

Of course, when an atom has lost an electron, it is very much dissatisfied and will pick up another whenever or wherever it may have a chance, and so become neutral again. When it loses an electron there is a large absorption of energy, and when it recaptures it this energy is given up. It is given up in the form of light, and thus we come to the conclusion that the light which we see in such electric discharges is not due directly to the breaking up of atoms and the consequent electric current, but rather that many of the broken-up parts refuse to remain broken up and on recombining give up



Dr. N. H. Williams, of the Research Laboratories of the General Electric Company, who has contributed to the work on the electron.

the energy which was stored in them. This, in brief form, is the present theory regarding the exceedingly beautiful light effects we get in electric discharge through gases.

Let us take up another subject. If we examine the light coming from a body such as the sun, by permitting it to pass through a glass prism, we find it is spread out into a spectrum or rainbow which is practically continuous. If we similarly examine the light which comes from an electric discharge tube such as we described above, we find that the spectrum is not continuous, but consists of narrow, bright lines with large, dark spaces between. We find that the arrangement of lines is different for each kind of atom or element, and that the spectrum for one substance is so characteristic that it serves as the best identification for the presence of any kind of atom, *i. e.*, it is virtually

Dr. A. W. Hull, co-worker with Dr. Williams, who developed the Magnetron power tube and obtained further data on the electron.

a thumb-print of an atom. Thus, by examining the spectrum of the light from stars, we can tell what elements are there.

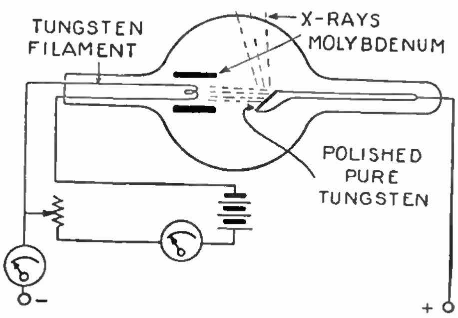
What explanation can we give for these characteristic spectra? I mentioned a moment ago that when an electron is knocked out of an atom, it takes up energy and that when it falls back into the atom it gives this off as light. According to the quantum theory as developed during recent years, the color or wave-length of the light which is given off depends on how much energy the electron gives up, and this will depend on the particular kind of atom—*i. e.*, the particular element into which the electron falls. It will also depend on what particular part of the atom it falls into. Thus we have the situation that at least several bright lines in the spectrum can be obtained from an element depending on which of its electrons was knocked out, and that these lines will be different for and characteristic of each element. This electronic explanation of the important phenomena of the origin of spectra is the first and only satisfactory one we have had.

Let me call your attention to another phenomenon—the Aurora Borealis—or Northern Lights—which we do not see frequently so far south as this, but which gives rise to such gorgeous and overwhelming displays in the far north. While it was recognized that these were connected in some way with magnetic disturbances, no good explanation for the effects had been put forth. Quite independently of this it had been shown that light, such as that from the sun, exerts a very minute pressure when it falls on a body.

*Head of Physics Department of Union College, Schenectady.

This pressure is too small to produce a noticeable effect on ordinary bodies. If the body is very small, however, then the effect is more important. Particles even as small as atoms would not be affected much, but it was pointed out that particles as small as electrons would be driven out from the sun in larger quantities during magnetic storms there. When they reach the earth's atmosphere they would have high velocities, sufficient, especially in the earth's polar regions, to break up or ionize some of the air in the upper atmosphere. Recombinations would now take place and the energy given up would show itself as light.

I wonder how many of you have ever asked the question as to how electricity is brought through the copper wires to your house, or how it is conducted through the fine tungsten wire in your lamps? For a good many years we have been able to generate electricity in large quantities, to control it by switches, to carry it from one place to another, to make it do work for us in various ways; but until recent years, we had no theory, even approximately satisfactory, for explaining how electricity is transferred through a conductor. In the case of electrolysis in liquids we knew that charged atoms or radicals moved in one direction or another, carrying their electric charges with them, but it was impossible to think that in a copper wire the atoms could be moving in sufficient numbers or with sufficient velocities because of their size and the strong forces holding them in place. With the discovery of the electron, however, we had very much smaller particles and these might work their way




**A very important use of electrons is in X-ray tubes.**

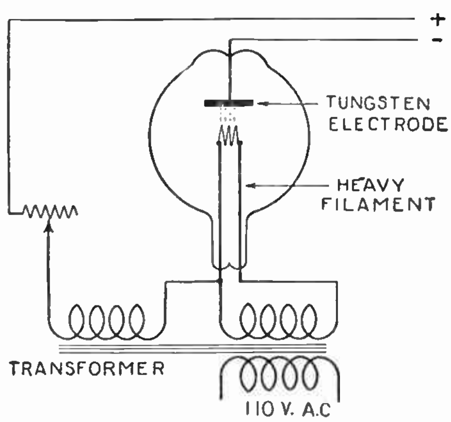
between the much larger atoms. The present theory of conduction through metals, then, is that metal atoms are able to lose an electron quite readily and that in a copper wire, for example, there are present a large number of free, or nearly free, electrons. When an electric field or voltage is applied to this wire, the electrons move in large numbers through the wire and thus bring to us the electricity, and, through this, the electrical power which we so much desire.

I have given a few illustrations of the application of the idea of electrons to various phenomena. Many others could be given if we had the time. Enough have been discussed, however, to show that the conception of the electron has led to plausible explanations of otherwise mysterious effects, and new physical theories have been brought our correlating many facts and enabling us to think of new lines of study. As a result, our civilization stands out as marked by the amazing scientific progress of this century and there is no reason to believe that we have exhausted the stimulus given to science by this great discovery.

## FOURTH LECTURE

### Sources of Electrons and Their Practical Applications

THE study of nature through the scientific method is a wholly good and justifiable thing in itself, quite apart from the useful applications of new information which follow so quickly in these days; for, anything which throws light upon and gives us a better understanding of the wonderful universe in which we live broadens our intellectual and spiritual horizon and makes life more worth while. Most of us, however, find a still greater satisfaction in the increase in knowledge if, at the same time, it is made available for increasing the comfort and well-being of mankind.




**Bulb rectifiers depend upon the uni-lateral conductivity of electronic emission.**

If this is true, then indeed we should have a great interest in studies on "electronics," for already the electrons have been put to work for us. Of course, one would expect that a thing which is so common and universal as the electron—in that it is a part of every atom—should be important for us, but I have in mind the use of electrons directly, *i. e.*—separated from their atoms, and it is on this, that I will speak. Before doing so, let me take up the matter of sources of electrons and how we can get them.

It might be expected that any kind of atoms, *i. e.*, any substance, could be used as a source of electrons; and this is so, although some substances are better adapted for this than others and certain methods of treatment are preferable. We can obtain electrons from gases by the method described in connection with J. J. Thomson's experiments. There, you may recall, he made use—in part—of the small amount of natural ionization or breaking up of atoms into electrons and positive ions. In the presence of a strong electric field applied by two electrons, these gain sufficient velocity so that on collision with neutral gas atoms they ionize or break them up, and so the number of electrons and ions rapidly increases. This, then, is one method of obtaining electrons in large numbers, although mixed with positive ions.

Practical use is made of this particular effect, for the positive ions and electrons tend to recombine, and, as explained in my last talk, the energy of recombination may be given off as visible light. This has been used in several forms of lamps, such as the mercury vapor lamps, those greenish blue lamps which are used in some factories and which one sees in many photographers' studios, their peculiar color being characteristic of the spectrum of mercury. It also plays an important part in arc lights such as are used for street illumination.

Another way in which electrons may be produced is by bombarding a solid—especially metals—with a few positive ions or electrons obtained from gases. This is an important factor in the arc lighting just mentioned. Some of the positive ions obtained from the gas strike the carbon rod or other electrode with sufficient velocity to knock electrons from the atoms of the solid. These electrons then get into the gas and help to keep up the further ionization of the gas molecules.

Still another method by which we may obtain electrons is to allow light to fall on a metal plate. Thus, let us take a zinc plate and allow light of very short wave-length, such as that called ultra-violet light, to fall upon it. Immediately electrons come off from the plate with quite a high velocity. This is spoken of as the *photo-electric effect*. As electrons leave the metal, it is rendered more and more strongly charged positively and thus the electrons find it harder to get away, until finally the action ceases. If, however, the plate is connected to the negative end of a battery and a neighboring plate is connected to the positive of the battery, the electrons will continue coming off. The effect does not depend on the presence of gas and so if the plates are put in a highly evacuated vessel, we get a pure electron stream without the presence of any positive ions. Some metals, such as potassium, are very sensitive to light in the visible part of the spectrum. In all cases, we find the number of electrons—*i. e.*, the electric current—is proportional to the amount of light falling on the metal plate. Thus it may be used in the reverse way for measuring the amount of light coming from any source, and it has been so used with some success. The photo-electric effect, as shown in so-called photo-electric cells, has also been an important element in the best systems for sending pictures by wire or by radio, concerning which you have no doubt read much lately. In addition, the photo-electric effect has been studied very extensively by physicists because of the information it has given us on the nature of the electron and the atom, and the nature of light.

(*Continued on page 248*)

**Dr. Wold, in front of the microphone at WGY, broadcasting "The Voice of the Electron." A rotating, perforated disc through which a stream of light is allowed to pass operates a photo-electric cell which converts the light energy into electronic energy and results in the production of musical notes.**

# Polarization of Radio Waves

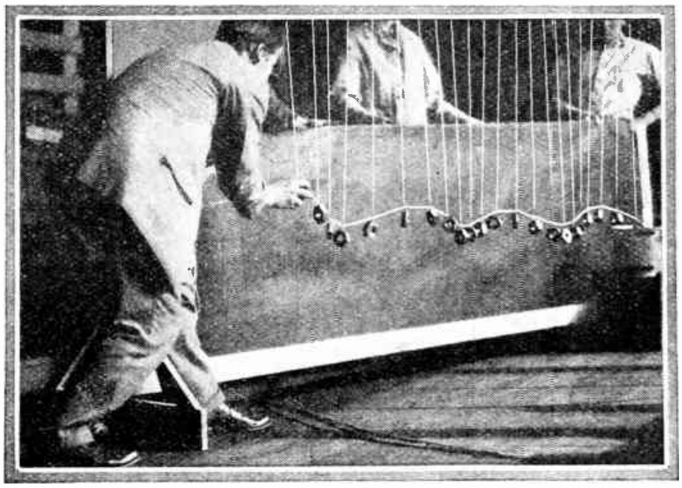
By E. F. W. Alexanderson*

RADIO development has, during the last year, entered into a new phase. Until recently, most efforts were devoted to apparatus in the sending and the receiving ends. In this respect, the radio technique has already reached a high degree of perfection. The milestones in this development have been the introduction of continuous wave transmission and reception, and of radio telephony for broadcasting.

Thus, a large industry has grown up, making practical use of wave propagation through space, a phenomenon of nature which was very little understood. About two years ago, a determined effort was made to shed new knowledge on this subject upon which the further growth of radio depends.

One of the first results of this effort to study the phenomena of wave propagation led to the discovery of horizontally polarized radiation. Since these discoveries were first announced, the subject of wave polarization has been brought into the limelight and is receiving much attention from radio investigators, amateurs as well as professionals. A wave of optimism has swept over the radio fraternity and brings forth new reports of success in the struggle against the old enemies of radio—static and fading.

The study of wave propagation over large distances requires a comprehensive, organized effort. To this end, the General Electric Company undertook to do the technical pioneer work in devising new forms of radiators and receivers. It has become a tradition among radio communication engineers to accept the judgment of traffic operators as final in valuation of the quality of a radio circuit. The reason for this is that the facts in regard to radio communication are not simple measurable phenomena such as we are accustomed to in most other engineering arts, but are statistical averages. The traffic operator measures how many words per hour and per day he can transmit over a radio circuit with a required degree of reliability, and the statistical results so obtained are as definite and reliable as the mortality figures of an insurance company, whereas, the radio engineer, when he is called upon to cure a bad case of static or fading, is in about the same position as a doctor in relation to his patient. This makes his profession all the more fascinating, and the science dealing with the diseases of radio is making rapid strides.



A mechanical model set up in the General Electric Laboratories by Mr. Alexanderson, who studied wave motion in various planes. Mr. Alexanderson has gone to some length in this article to show a striking comparison in the waves as set up by the model and in the radio waves.

### Short Waves

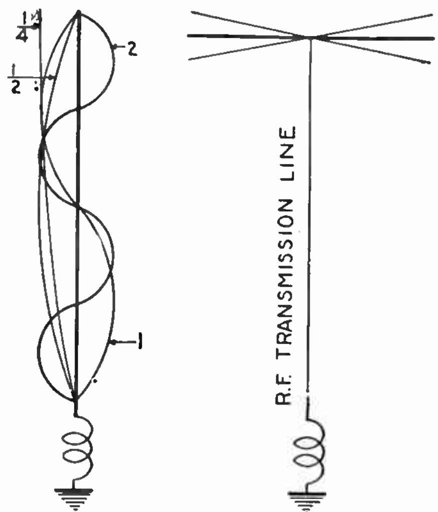
One of the important steps in exploration of short waves was taken when six short-wave transmitters were installed in a temporary manner. These transmitters were, to begin with, operated in the neighborhood of 100 meters. Similar transmitters were installed in Europe.

Some of these transmitters were kept in regular service, whereas others were modified in order to explore possibilities of improved results. Thus it was found that, when the wave-length was below 50 meters, the night signals became weaker, but, on the other hand, service could be given during daylight hours. Tests with still greater reduction of wave-lengths of a range between 15 and 30 meters proved that it was often impossible to give good service across the Atlantic Ocean at mid-day in the summer. The stations which are giving the best all-around service at the present time operate at a wave-length of about 40 meters.

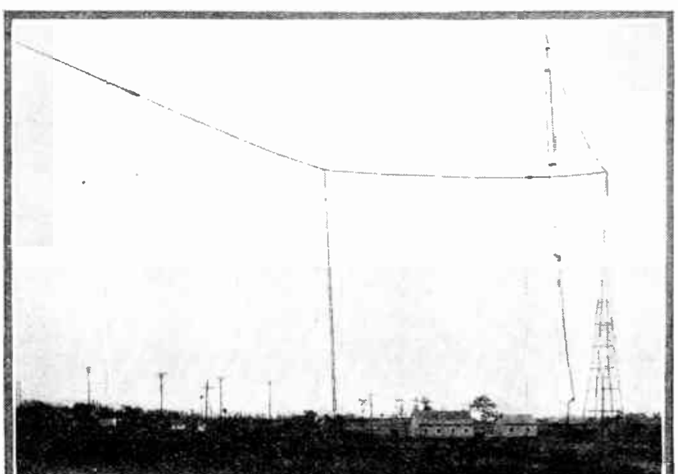
### New Antenna Systems

The experimental station built by the General Electric Company in Schenectady for the purpose of exploring these possibilities is now capable of operating with seven transmitters simultaneously with different wave-lengths and different types of radiators, and observations from these transmission tests are being made all over the world. The object of these tests is partly to explore the propagation characteristics of different wave-lengths and partly to make final tests of comparison between various types of radiators. Three types of radiators are used in these comparisons, and these are the result of a sifting process conducted on a smaller scale, in which a great many other antenna systems have been explored and, at least, temporarily discarded. The radiators which are now being compared are:

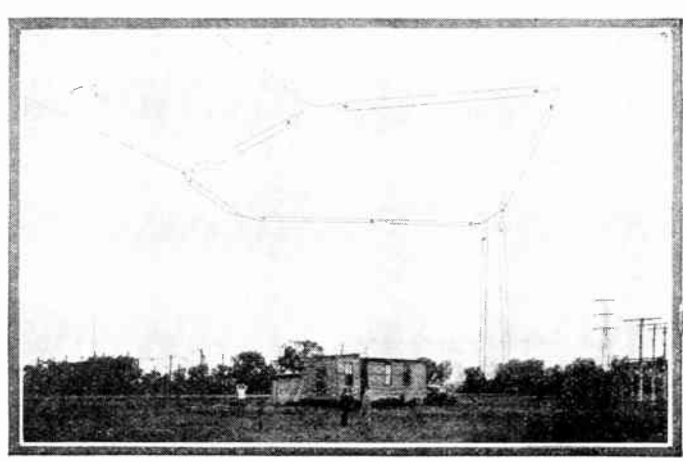
1. The straight vertical antenna oscillating at a harmonic frequency.
2. The horizontal antenna with an over-all dimension of one-half wave fed in the middle through a transmission line.
3. The series-tuned horizontal loop.




Two of the types of antennae used in the experiments and operated at harmonic frequencies.



Showing the horizontal antenna fed by a radio frequency transmission line in its exact center and, to the right of the photo, the vertical cage radiator with which the tests on radio wave polarization were made.



The horizontal loop antenna which was used to obtain horizontally polarized waves and which may be the forerunner of transmitting antennae of the future. As can be noticed, the loop is a series of caged structures.

*Consulting Radio Engineer, General Electric Company.

All these three radiators have one feature in common, that the radiation is projected at a high angle upward. They may, therefore, all be classified as high-angle radiators. It has been found that only the high-angle radiation is useful in reaching great distances. The high-angle radiator has, therefore, the double advantage of economy of energy and the absence of objectionable signal strength in the neighborhood of the station.

The first type of antenna radiates a vertically polarized wave of the same general character as the waves that have been used heretofore in long and intermediate wave stations. It differs from the old type of operation only by being a pure high-angle radiator, whereas the old type of stations radiated a ground wave as well as a high-angle wave.

The second type of antenna, the half-wave doublet, is an intermediate form. At right angles to its length-direction, it radiates a horizontally polarized wave, and in its length-direction, it radiates a high-angle vertically polarized wave. Thus, in its length-direction, it has a radiation of the same character as that emitted from the vertical high-angle radiator, whereas, in the broadside directions, it emits a wave of different type.

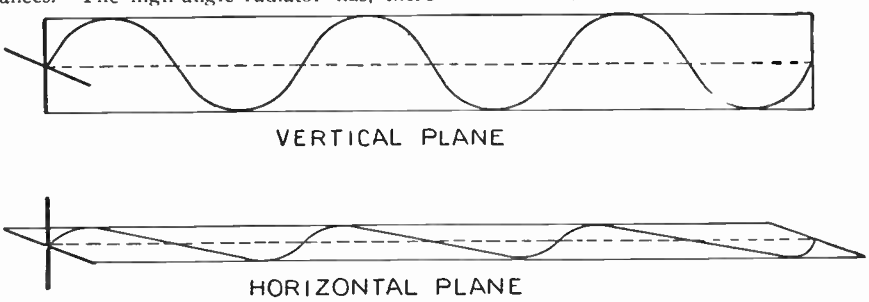
The third antenna system, the horizontal series-tuned loop, emits a horizontally polarized radiation in all directions.

For the analysis of the characteristics of high-angle radiation, we are particularly indebted to Commander A. Hoyt Taylor, of the Navy Department, who has made extensive tests and furnished valuable data on the so-called "skip" distance of the wave. He has found that the distance skipped by the wave, which means the line on the earth's surface from the beginning of the trajectory to where the high-angle radiation comes down again to earth, depends upon the wave-length, day and night conditions, and summer and winter conditions, the general rule being that the shorter the wave, the greater is the skip distance.

### Measurements of Wave Propagation

The characteristic of the horizontally polarized waves has been explored in the neighborhood of the station in Schenectady up to about ten miles, and also by measurements in the various stations of the Radio Corporation. For measurements of wave polarization at long distance, we are indebted to Dr. Greenleaf Whittier Pickard, who, during last summer and fall, has made systematic tests of the radiation sent out from Schenectady, as well as generally explored the conditions of wave polarization. His findings have been presented to the Institute of Radio Engineers and it may be sufficient to mention that he has shown that, in the short-wave range, the horizontal component of polarization is usually twice as strong, and sometimes ten times as strong, as the vertical wave. He has also shown that fading conditions are different in the horizontal and the vertical plane.

Dr. Pickard has also shown that the wave does not maintain its original plane of polarization because the reception appears to be of the same nature, regardless of whether the wave is radiated with a horizontal or a vertical polarization. These findings are in agreement with the original observation which led us to study horizontal polarization when it was found that a horizontally polarized wave from Schenectady was received with greater intensity on Long Island than the ordinary vertically polarized wave, although in both cases a vertical receiving antenna was used.




**Results of experiments with the mechanical model for wave analogy. Waves started in either the horizontal or vertical planes maintained themselves in their respective planes.**

### Phenomena of Wave Polarization

Explorations of wave polarization in the neighborhood of the station have brought out many peculiarities which have not yet been fully explained. So, for example, it is found at a distance of about ten miles from the horizontal loop radiator, that the wave comes down with an almost vertical direction of propagation. For those who believe in a reflecting Kenelly-Heaviside layer, this would appear to be good evidence, because it might be assumed that the wave has been radiated straight up from the station and is reflected directly downward. A loop-receiver, under those conditions, gave no orientation of the station whatever, because the signals came in, apparently, equally strong from all directions when the loop was rotated around its vertical axis. This would indicate that the wave, besides being vertically propagated, was circularly polarized.

**Of great importance were the field measurements on the strength of the radiated energy in the vicinity of the transmitter. Note compact and portable equipment.**

Similar observations at a point only a few wave-lengths distant from a horizontally radiating loop show that the wave comes down nearly vertical, but yet with a definite slant toward the station. Tests with a loop receiver gave, in this case, a distinct orientation, but the station appeared to be located at right angles from its proper orientation.

One of the loop-radiators used in these tests is round, another is about one-sixth wave-length wide and two wave-lengths long. These horizontal loop-radiators also differ from the ordinary types of antenna by radiating on the magnetic component of the wave. An ordinary long-wave antenna creates an electrostatic field around the station, whereas, the magnetic counterpart of the magnetic energy is confined to a tuning coil. In the series-tuned loop radiator, this process is reversed. A magnetic field is created around the antenna, whereas, the electrostatic counterpart of the oscillations is confined to artificial condensers inserted at regular intervals in series with the antenna conductor.

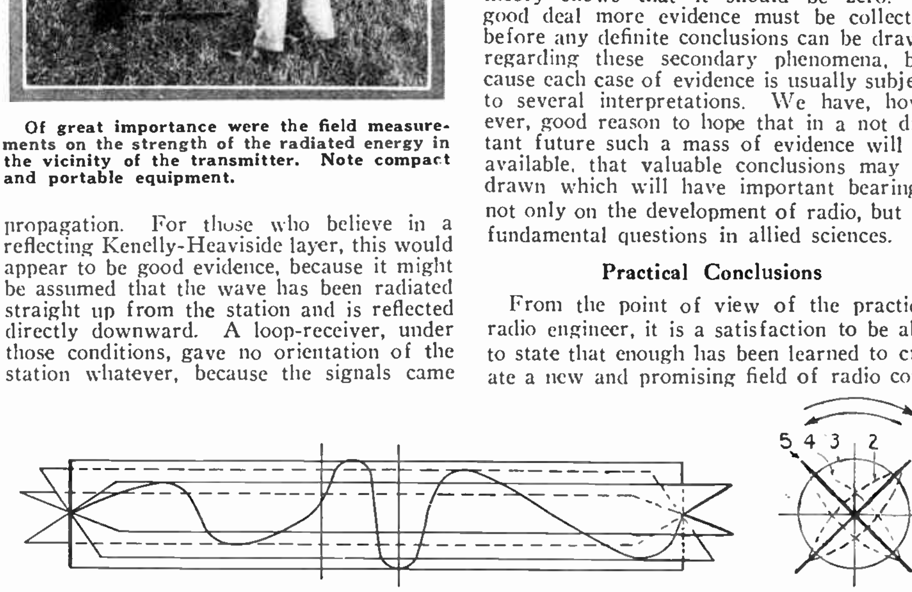
One advantage of confining the electrostatic field to artificial condensers has been found to be due to the fact that the antenna is much less subject to fluctuations in its natural period, due to swaying of the wires in the wind. The radiation produced by these loops has a pure horizontal polarization. The oblong loop projects its principal radiation 45 degrees upward, broadside to its own length-direction. Reception tests have proven that it is superior to the vertical radiator. From the elementary theory of directive radiation, it would be possible to calculate a quite sharp directivity diagram for this antenna. Such a result was, however, not expected in reception tests at long distances, because experience with a variety of types of directive antenna systems had proven that, whereas the theoretical directivity diagram can be easily confirmed in the neighborhood of the station, the distant measurements do not bear out the elementary theory.

The reason for this seems to be that, while the antenna sends out a radiation as calculated, there is an additional radiation which is projected almost vertically upward and then scattered in all directions by the upper layer of the atmosphere. Signals may, therefore, be received at distant points in directions where the elementary theory shows that it should be zero. A good deal more evidence must be collected before any definite conclusions can be drawn regarding these secondary phenomena, because each case of evidence is usually subject to several interpretations. We have, however, good reason to hope that in a not distant future such a mass of evidence will be available, that valuable conclusions may be drawn which will have important bearings, not only on the development of radio, but on fundamental questions in allied sciences.

### Practical Conclusions

From the point of view of the practical radio engineer, it is a satisfaction to be able to state that enough has been learned to create a new and promising field of radio communication. Stations, which will shortly be built, will have antenna systems of the type classified as short-wave, high-angle radiators. Which one of the three types discussed above

*(Continued on page 247)*




45° PLANE

**A wave started in the 45-degree plane maintained itself in that plane only for a short time, but passed through the series of changes as shown.**

# Oscillation Control and Antenna Coupling

**By A. P. Peck, 3MO, Assoc. I. R. E.**

EVERY once in a while we pick up a radio magazine or a newspaper supplement, particularly the latter, and read about some new "Plunkadyne" or "Zuludyne" receiver that some promising young "radio engineer" has designed and which will enable the builder of one to receive from *every* station in the world and possibly a few on the nearer planets! This may be exaggerated a little, but you undoubtedly get the idea.

Analysis of the circuit diagrams of "new" receivers usually shows the initiated immediately that there is nothing at all new about the circuit and that it is based upon old and very well known principles. This almost without exception has been true of every receiver designed in the past three or four years and adapted for either broadcast or amateur wave reception. And so, we are very much of the opinion that a resumé of the essential parts of the various types of standard circuits will not be amiss here.

We have chosen to dwell upon the two parts of radio circuits designated in the heading of this article, oscillation control and antenna coupling. These are really two things of importance in radio circuits, particularly for short wave or amateur reception. Of course, there are a few other variations of the several circuits which we show in these columns, but practically all of them are minor changes. If you will study the circuit diagrams given, and read the following text carefully, you will quickly note the similarity betwen our diagrams and those that have been advanced at different times as being new.

Let us first deal with the question of oscillation or regeneration control. This should be of particular interest to the amateur, inasmuch as ease of oscillation control is a most important factor in C.W. (continuous wave) reception. To the broadcast listener, regeneration control, which is nothing more than the first part or beginning of oscillation control, is not quite as important, inasmuch as he will usually get very good results even though the control be not so critical or sensitive as it could be. With the amateur, however, the vacuum tube must be worked at its most sensitive point, at a place where the detector tube has just started to oscillate, and unless we work the receiver on this point or peak, as it might be called, the receiver will not be very sensitive and the results will be very inferior. If, on the other hand, the set is so designed that the oscillation control is very smooth and accurate, there is no trouble at all in bringing in very distant C.W. stations at their loudest and with the least interference. Operating at just the oscillation point of the detector tube increases the sensitivity as well as the selectivity of the entire circuit enormously and produces some excellent results.

Before dealing with the various circuits shown here, the writer desires to stress once more a most important point in C.W. reception. That is, that the grid-leak *must* be of the correct value for the particular detector tube employed. If it is not, you will find considerable trouble in operating the receiver correctly and in getting the best possible results from it. Of course, the obvious thing to do is to use a well-made variable grid-leak rather than those of the fixed type which are often far from the value they are rated at. One must be employed which is variable continuously, not by steps, and which will hold its setting after it has been once correctly adjusted. In the writer's opinion, there is nothing better than a variable grid-leak of the carbon or graphite pile type such as the Bradleyleak. This type of instrument will almost invariably hold its setting after it has been once adjusted and will give no trouble whatsoever. After you have once adjusted it so that the set goes into oscillation with a soft hiss rather than with a loud plop, the leak need not be touched again until the detector tube is changed. Find this point before you condemn the particular set that you are working with.

Now let us consider the circuits shown, beginning with Fig. 1. In all of these, we have shown only those parts essential to the description. Filament circuits and amplifiers have been eliminated. Fig. 1 will be immediately recognized as our old friend, the tickler feed-back type of regenerative receiver. This is in wide use today among both amateurs and BCLs (broadcast listeners) and certainly is deserving of its popularity. Cheap to construct, it is most efficient when properly made. However, there is one bad feature about it and that is the difficulty of constructing a satisfactory type of tickler coil that will be smooth in its mechanical operation and to which satisfactory electrical connections can be made.

The average home-made tickler coil is a floppy sort of thing that more often than not falls out of adjustment when somebody happens to walk across the room a little too heavily or slams the door. In the manufactured type of coil, however, these troubles are practically overcome, but we won't consider that here, because the average amateur likes to at least experiment with different types of circuits and then he usually builds his own coils. Furthermore, another drawback to the type of circuit shown in Fig. 1 is that while the control of regeneration is good, still when the tube starts to oscillate, this type of receiver cannot be worked directly on the point of oscillation as easily as we might wish. Therefore, in short wave amateur work, this type of receiver, while it gives fair results, cannot always compare with other types. Its one main advantage is its low cost.

In Fig. 2 we show a variation of the feed-back circuit of Fig. 1, in which the tickler coil may be fixed in its relationship to the secondary, whereupon regeneration and oscillation are controlled by means of a variable resistance connected directly across the tickler coil. This resistance is usually on the order of 10,000 to 100,000 ohms and should be continuously and smoothly variable in order to achieve the best results.

Still another variation in the feed-back circuit is shown in Fig. 3. Here the tickler coil is again fixed and the objectionable variable tickler is done away with. Oscillation is controlled by means of a variable condenser in shunt or parallel with the tickler coil. When using a receiver of this nature, the tickler coil should have fewer turns than those of the usual type. This receiver is quite widely used and usually gives excellent results when properly used.

We will now leave the types of receivers that depend upon the well-known feed-back principle in its usual form and discuss several other kinds which, while their ancestry may be traced back to the feed-back receiver, still do not take just exactly that form. One of these is shown in Fig. 4, wherein the secondary and plate coils are both wound on the same form and are one and the same coil. A center tap provides for the filament connection and a variable tuning condenser is connected across the entire inductance. This is another receiver that is quite often used, but we find one more drawback here. Unless the variable grid-leak is changed for the reception of different wave-lengths, the detector tube is not worked at its most efficient point for C.W. reception and, therefore, the results are often inferior.

It is to be noted in connection with this circuit that a radio-frequency choke is connected in series with the phones. This prevents the entrance of radio-frequency current into the phone circuit and stabilizes the operation of the receiver. The radio-frequency choke is indicated by R.F.C. in this and succeeding drawings and can occasionally be omitted. More often than not, it is necessary. For all-around work on the 40- or 80-meter amateur band, use 100 turns of No. 30 S.C.C. wire, wound on a 1-inch form. For the upper amateur band and for broadcast work, use about twice this number of turns. If you find that your receiver does not oscillate over the entire band, increase the number of turns on the choke coil. Such operation indicates that the choke coil is in resonance with the incoming signal. Changing the construction, of course, throws this wave-length off and the trouble will usually disappear. The circuit shown in Fig. 4 is usually referred to as the Hartley circuit and is used in transmission as well as reception.

The Colpitts circuit is another one that has been used successfully for both trans-

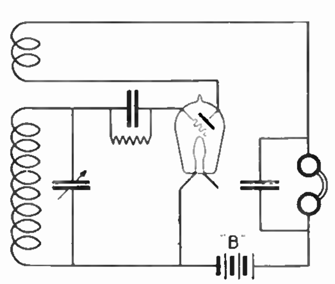



FIG. 1

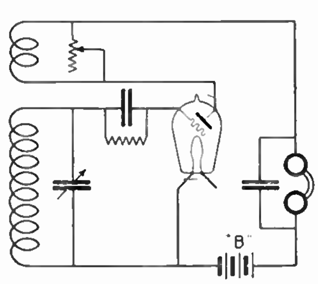



FIG. 2

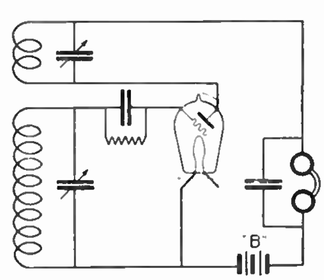



FIG. 3

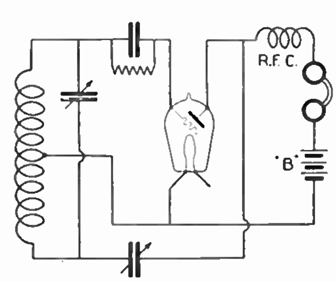



FIG. 4

**The four drawings above show different methods of regeneration and oscillation control. Figs. 1, 2 and 3 use tickler feed-back, while Fig. 4 is a Harley circuit adaptation. It is also a transmitting circuit, and needs few if any changes to enable its use for this purpose.**

mission and reception and it is shown in Fig. 5. Here a fixed coil is used and is connected between the grid and plate leads as shown. A variable condenser connected from grid to filament terminals provides a tuning control and it must be noted that the grid-leak is connected from the grid lead to the filament lead instead of across the grid condenser. This is necessary in this circuit. Anyone who tries to use this type of set should be sure to employ a well-made grid-leak as it will have to be changed in accordance with wave-length variations. Also use a vernier type of rheostat or one that gives very fine control such as the carbon or graphite disk type. Variation of the filament current will produce variations in oscillation that may often be found necessary when receiving on certain wave-lengths. In this circuit also, an R.F. choke is employed.

And now we come to the so-called Reinartz receiver, named in honor of the well-known amateur who made its use so popular, John L. Reinartz, owner and operator of Stations 1QP and 1XAM. The fundamental circuit of this receiver is shown in Fig. 6. Here we find about the best type of oscillation control employed that it is possible to construct. We do not have to worry about the construction of a tickler coil as all of the inductances are fixed in relationship to each other and we can have the finest possible oscillation control. Variable condensers are usually well balanced and by turning the one connected in the plate circuit of the detector tube we can bring that tube right up to and past the oscillation point, operating it in the most efficient manner.

The writer and other amateurs have found one big drawback in the Reinartz receiver, particularly in use for short waves. While this is a good set to build up for any wave-length between 20 and 600 meters, still when we get below 200 meters, we find that the capacity effect of the hand near the dial controlling the feed-back condenser is so great that trouble is experienced in properly controlling the set. Therefore, without destroying any of the good qualities of this receiver, we merely reverse the positions of the plate coil and condensers. In other words, we connect the condenser to a point where it will be at lower potential and place the inductance between it and the plate. This final circuit is the one shown in Fig. 7 and by employing it, connecting the rotor plates of both condensers together and to the filament circuit, absolutely no body capacity will be noticed. The tuning can be carried on with the greatest of ease and the hands can be kept on both dials at all times without affecting the operation of the set in any way.

And now you have the details of the seven most prominent methods of controlling regeneration and oscillation. Let us now turn to the methods that can be employed for coupling circuits of the types that we have discussed, to antenna systems. In Fig. 8 we show what is probably the oldest method of accomplishing this. The antenna circuit is tuned to resonance with the incoming wave and loosely coupled to the secondary. Such a method, however, introduces more controls than are to be desired, particularly on short wave sets. Therefore, in our search for something simpler and just as good, we next progress to the type of circuit shown in Fig. 9. Here we do away with all additional antenna controls, but we find that the set will not operate efficiently on all wave-lengths, particularly on all near the fundamental of the antenna. Therefore, for the average set this type of antenna coupling can be disregarded. We merely show it so as to make our series complete.

As stated before, if we want to get away from any controls that can possibly be eliminated, we must find some way of doing away with the antenna tuning controls. Therefore, something on the order of that shown in Fig. 10 can be employed. This circuit is similar to that of Fig. 9, but a very small condenser is inserted in series with the antenna. This condenser should have a capacity not greater than .0001 mfd. and it should preferably be smaller. On short-wave sets, some amateurs have used novel capacities in this circuit. For instance, two pieces of bell wire are twisted together for a few inches and one of them is connected to the antenna and the other to the grid end of the secondary coil. The capacity can be varied by twisting together more or less of the two wires which, of course, are not connected to each other. Another type of capacity to use in this circuit may be one consisting of two plates of brass or other metal one-half inch square and placed one-quarter of an inch apart, with their flat faces toward each other. This will give ample coupling for use on the short waves.

We cannot, of course, forget our old friend, the so-called untuned primary or shock excitation method of coupling the antenna to the secondary. Therefore, we illustrate it in Fig. 11. If the small antenna coil is not variable in its relationship to the secondary, and it need not be, the number of turns in it should be kept at a minimum. Usually, not more than three or four are necessary, and sometimes two are used on the 20- and 40-meter amateur bands. If too many turns are employed on this coil, it will again be found that the set will not operate satisfactorily at or near the fundamental of the antenna circuit. This is not desirable, inasmuch as the average amateur reception antenna has its fundamental somewhere in one of the bands upon which its owner desires to operate his receiver. This type of antenna should best be used with one of the coupling schemes shown in Fig. 10 or Fig. 11. In the writer's opinion, there is little difference between the two, as far as efficiency is concerned, and, both of them being simple to build, the choice will lie with each individual constructor. Some favor the coil coupling illustrated in Fig. 11, because they seem to think that there are less losses in it than in the capacity coupling scheme. However, the latter has been employed with excellent results in so many cases that it is hard to make a definite statement relative to the merits of the two and, therefore, we will not attempt to do so here. It is hoped that the reader will benefit by the suggestions made.

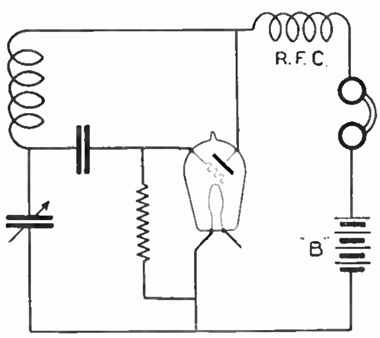



FIG. 5

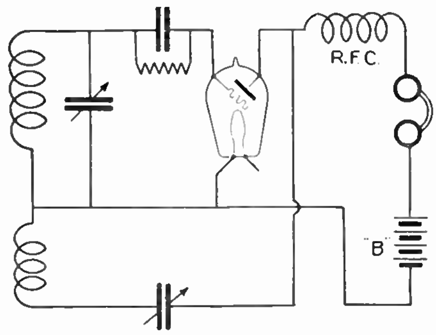



FIG. 6

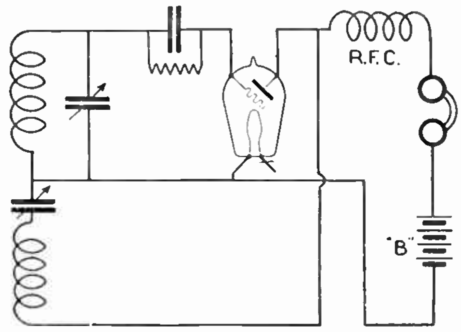



FIG. 7

**These three drawings show still more types of regeneration controls. All of these circuits are quite persistent oscillators and are particularly valuable for short wave C.W. reception. They can also be adapted to broadcast work if the builder desires to design coils for that purpose.**

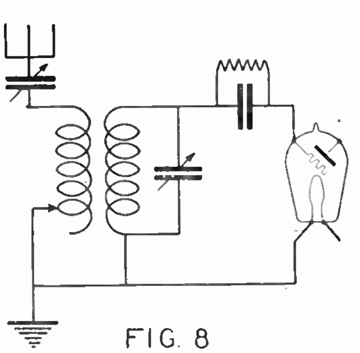


FIG. 8

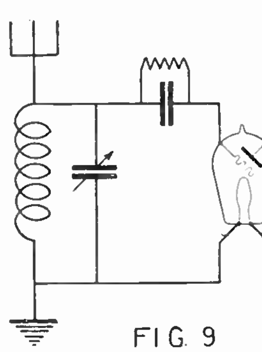


FIG. 9

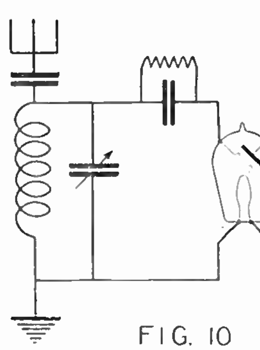


FIG. 10

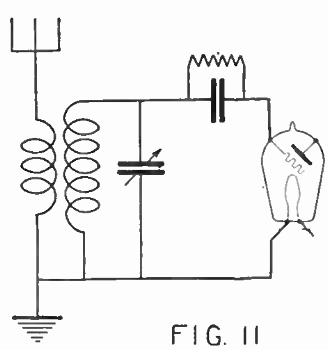


FIG. 11

**The four standard methods of coupling the antenna and ground to the secondary or oscillatory part of a radio receiving circuit are shown above. Any one may be used at the discretion of the builder. Their good and bad points are outlined in the text.**

# New Highest Radio Mast

By Lillian Mark

BY INCREASING the effective height of the antenna system, a marked increase in the distance attainable by radio communication on long wave-lengths is made possible.

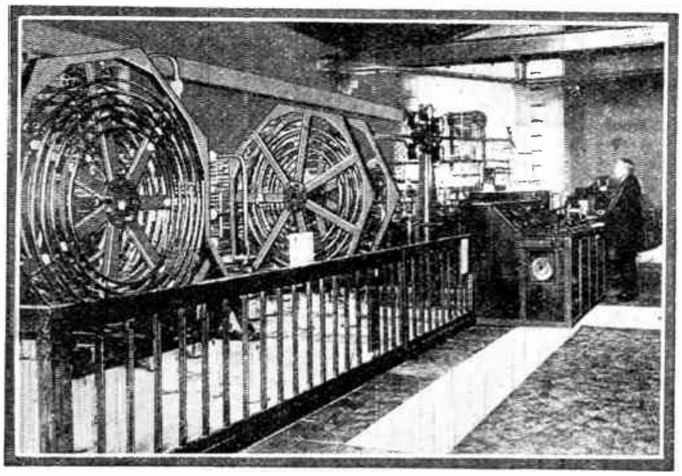
We are all aware that the Eiffel Tower in Paris is the tallest structure in the world, being 984 feet in height. How long this record will stand is but a matter of time, since contemporary radio construction firms are vying with each other in erecting masts as high as possible, the only limitation being expense.

One of the first of the gigantic radio installations having towering masts was erected at Wellfleet, Mass., in 1900. Its masts were of wood and about 400 feet high, there being four of them.

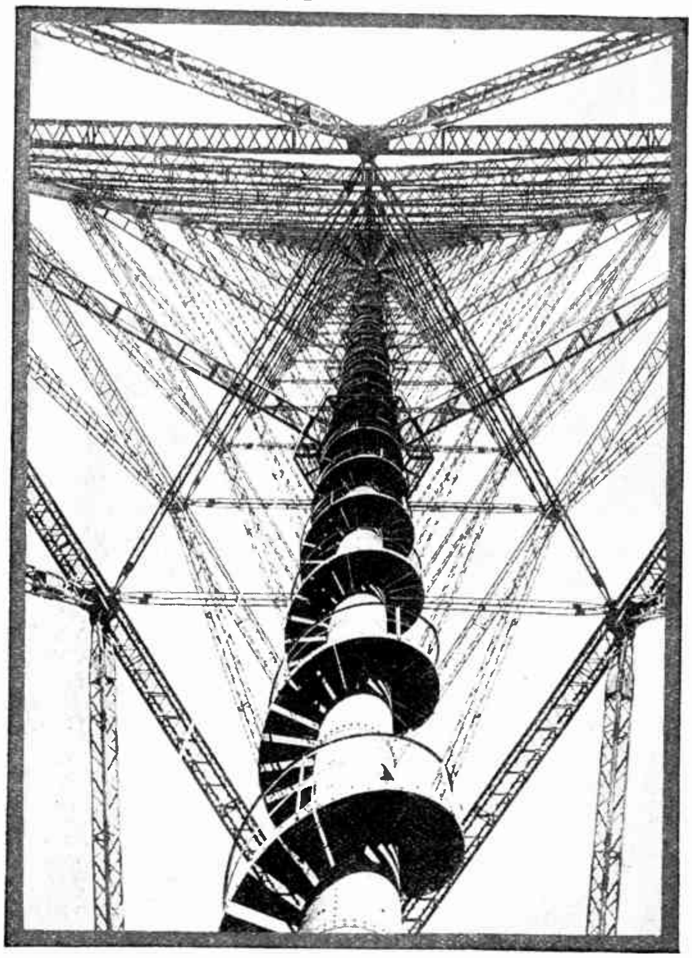
As time went on, the necessity for steel structures became imperative and gradually there appeared steel masts ranging upward to the height of 600 feet. Today, we witness at Tuckerton, N. J., a most imposing spectacle of immense towers ranging in height from 400 to 600 feet and distributed around and about a central mast 870 feet high. This is the highest radio mast in the country, eclipsing the Woolworth Building by more than 115 feet.

Recently, work was started to erect a mast near Berlin, having a total height of 927 feet, the upper part for a length of approximately 175 feet to be made of aluminum. Construction on this tower has already been started, and it is interesting to note, in comparison with the Eiffel Tower, that, while the weight of the latter is 7,000 tons, the new German structure will weigh only 700 tons.

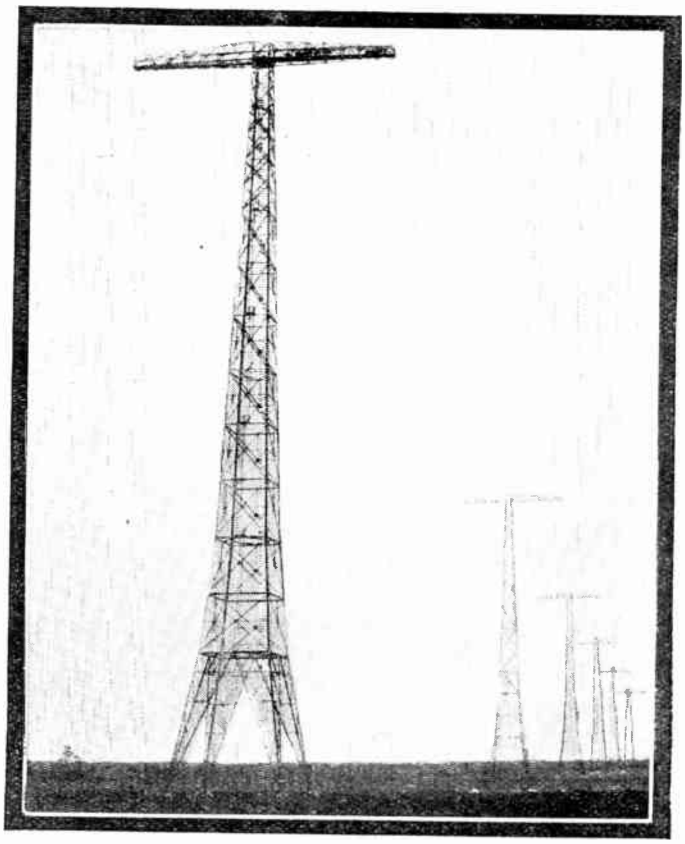
At Nauen, which is a few miles northwest of Berlin, is located what at present is the most powerful German radio station. Its masts are 600 feet high and support an immense antenna network which is suspended from a main structure 900 feet high.



The interior of the new German station at Koenigs - Wusterhausen showing the immense tuning inductances which will play an important part in carrying on regular communication with this country.



Splendid interior view gazing skyward of the tallest radio mast in the world, which is but 50 feet smaller than the Eiffel Tower. Particular attention should be given its excellent mechanical construction.



View of six of the gigantic radio towers at Rocky Point, Station WQK. They are each over 400 feet high and present a most interesting spectacle to the onlooker. The crossarms at the top are 150 feet in length and support eight wires on each side.

The new station at Koenigs-Wusterhausen will have the tallest mast in the world. As can be seen in the photo, it is of pyramidical construction and is most ingeniously cross-braced and constructed. It is self-supporting, and rests on a tripod base.

An interesting feature in the construction of the tower is the spiral staircase which goes completely to the very top. Within the pipe about which this staircase is built, is contained a small elevator, capable of taking up one person at a time.

A view of the large transmitting inductances to be used in the powerful station can be seen in a second photo. Note the exceptionally large size of pure copper tubing used to constitute the winding of the inductance. Commercial, trans-oceanic and world-wide telegraphic service with Germany will be insured upon its completion.

The construction of masts in various countries is radically different. Thus, in the majority of instances, the towers of radio stations in this country are self-supporting, requiring no guy-wires. An excellent example of this type of installation is that of Radio Central at Rocky Point, Long Island.

In England, the tubular mast is much used and, of course, along with it are many guy wires to ensure its stability. An example of this is shown at the Rugby station, where a mast 820 feet high is supported by an extensive network of guy-wires.

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# The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

## ON THE TENDENCIES OF RADIO DESIGN

THERE are a great number of units in general use in the radio theory and practise which it is very necessary to understand before one can be able to handle the various problems that arise in radio design, or even in order to handle a radio receiver intelligently. It is the ambition of most manufacturers of radio receivers to turn out receivers that "even a baby can operate," but in the estimation of the writer, there is a limit beyond which this idea should not be carried.

For instance, take the case of the automobile. There are many women drivers throughout the world, many of whom are really competent drivers. But women are, in general, at the present time anyhow (even though they are showing tendencies toward becoming technically or mechanically inclined), not disposed to be technical, nor are they apt to possess a desire to learn the theory and mechanism of gas engines; nevertheless, after they have learned how to manipulate the clutch, gear-shift and brakes, and drive a car for a year or so, they soon become able to talk about flat tires, worn piston-rings and stripped gears as volubly as any man.

So, in spite of all that is said and done, automobiles still remain, and are likely to remain so for a long time to come, far more difficult to operate than even a complicated radio receiver. To attempt to make them less complicated than they are will, besides making the automobile less flexible to operate and limiting their usefulness, be paying a great compliment to the lack of intelligence on the part of those who operate them.

There have been certain tendencies apparent during the past few years, in the designing of radio receivers, many of which designs have been short-lived, and some few of which have survived and promise to endure for some time to come. Some of these tendencies were due to the ignorance of the designers of the receivers; others were due to the efforts of these designers to underrate the intelligence of the average human being, and others of these tendencies were really worth while. I am referring more particularly to what is on the front panel of the receiver, which, of course, is the most important part, as far as operation of the receiver is concerned. What is behind the panel is analogous to what is under the hood of the automobile; it *is* possible to learn to operate the automobile without knowing anything about what is under the hood; likewise, it is possible to operate a receiver without knowing what is behind the panel. But most success is obtained, and the receiver is operated most intelligently, when the operator has at least some idea about the mechanism behind the panel.



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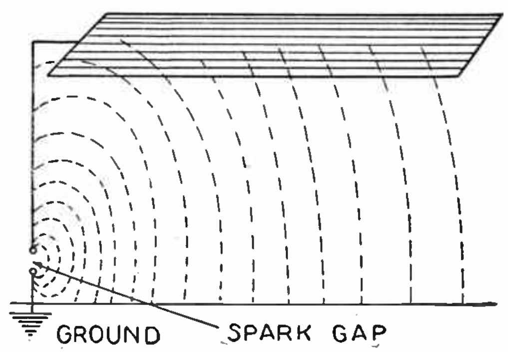
# The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

## THE ANTENNA

IN OUR studies of condensers, we have learned that when a difference of potential is established between the two plates of the condenser, there is an electrostatic field set up in the space between the plates. This electric field is called the *displacement,* and any variations in this displacement, due to variations of the potential difference between the plates, gives rise to a change in the intensity of this field (or displacement), which is known as a *displacement current.*

This displacement current is equivalent to a change in the condition of the medium between the plates, which, in many cases, is simply air. In fixed condensers, it is often mica. Furthermore, there is no displacement unless the condition of this field *is changing;* the condition of the field may be thought of as a stress in the medium, whatever this medium may be, which causes a certain deformation of the medium, called a strain. All this is analogous to the pressure (or stress) on an automobile spring, which causes an accompanying deformation (strain) in the spring.




The reason why we have reviewed all this about condensers is that the antenna is a condenser of large dimensions. The ground forms one of the plates and the flat top of the antenna forms the other plate. The vertical portion of the antenna called the *lead-in* plays its part also, indeed a very important part, as we shall see, especially insofar as the radiation of electromagnetic energy is concerned.

When the antenna is charged, this charge is distributed along its whole length in a very complicated manner. The distribution is not uniform, as we might be led to suspect, but is concentrated more at some parts than at others, depending upon the form and shape of the antenna, and the location of the receiving or transmitting apparatus in the ground-lead.



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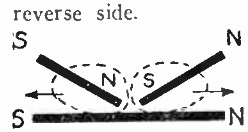
# The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

## MAGNETISM [Continued]

IN PREVIOUS Data Sheets, we have shown how bars or needles of steel were magnetized by simply touching them or stroking them from one end to the other with the pole of a permanent magnet. In this case, the last touched point of the bar or needle will be a pole of opposite kind to that used to touch it, and a more certain effect is produced if one pole of the magnet be rubbed on one half of the steel bar or needle, and the other pole on the other half.

But there are better methods, however, of inducing magnetism in a piece of steel. In one of these methods the bar to be magnetized is laid down horizontally and two bar magnets are held over it, as shown, their opposite poles being close together. The poles rest upon the bar. They are then drawn apart from the middle of the bar toward its ends, rubbing against the bar, and then back, through the air, the circuits being completed several times. The bar is then turned over and the operation repeated on the reverse side.




A METHOD OF MAGNETIZING A STEEL BAR

There are many types of magnets, the simplest being the natural magnet, or lodestone, which is a mineral, of iron, magnetic oxide ($Fe_3O_4$), generally of irregular form. The next simplest type is the bar magnet, such as the "needle" of the mariner's compass. In the horseshoe magnet a simple flat bar is bent into the form of a horseshoe, or "U," and is then magnetized; this shape makes it convenient to place across the ends of the horseshoe a small piece of steel or iron, which helps the magnet to retain its magnetism.

It is found that long, thin bar magnets are more powerful in proportion to their weight than short, thick ones. Hence, if a number of these long, thin magnets are clamped together, having like poles at the same ends, a composite magnet will be formed which is very powerful. These are called "compound," or "laminated" magnets.

It is possible to utilize the magnetism of the earth for magnetizing an ordinary bar magnet. It has been found that iron bars set upright in the magnetic meridian, about north and south, for a long time acquire some magnetism from the earth. If a steel rod be held pointing north and south, and inclined at an angle of about 45 degrees (for this part of the United States) it will point, approximately, toward the magnetic North Pole, and if it then be struck on the upper end by a wooden mallet very forcibly, it will be found to have become magnetized.

# The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

## ON THE TENDENCIES OF RADIO DESIGN [Continued]

THE most important of these tendencies, at least as concerns the broadcast listener, who is not supposed by the manufacturer to have sufficient brains to comprehend what is going on behind the panel, is the attempt to simplify the operation of the receiver in reducing the number of controls.

The way in which this is generally accomplished is to use ballast resistances in place of rheostats, to use filament control jacks, and to use gang condensers in the tuning angles, or, if a number of separate variable condensers are used, they are geared together or worked simultaneously through pulleys or cords.

The matter of controlling the filaments by means of ballast resistances is perfectly feasible, for the development of the "hard" tube has made this possible. The hard tubes are not influenced appreciably by small changes in terminal voltage, such as occur between the full and low states of charge of the average storage battery. Then, also, the cost of these ballast resistances is hardly greater than the cost of the rheostats, which would be necessary if they were not used, so that, all in all, the operation of the set is made simpler, without increasing its cost.

On the other hand, when it comes to using filament control jacks, although the receiver is made more nearly automatic, there is no doubt that this practice increases the cost of the receiver, on account of the more intricate wiring and the greater time required in assembling. To tell the truth, a little inoffensive filament switch is hardly anything to find fault with on the panel of the receiver as in making the operation of the set more complicated, and if we try to consider the saving gained by the filament control jacks in conserving the "A" battery power, the argument becomes farcical, for this additional cost is negligible.

The greatest attempts that have been made toward reducing the number of controls has been in trying to use gang- or multiple-control of the tuning condensers. It is evident that if the inductances in a receiver did not vary, it would be possible to control several variable condensers simultaneously, providing that it is possible to construct condensers so exactly alike that they have *identical* capacities at identical settings. But nothing in this life is perfect, so that we can hardly expect to ever operate a radio receiver under such ideal conditions.

For this reason, it will be found that in nearly all cases where gang or multiple tuning is employed, the resistances of the circuits are made so high that the resulting broadness of tuning makes gang control possible.

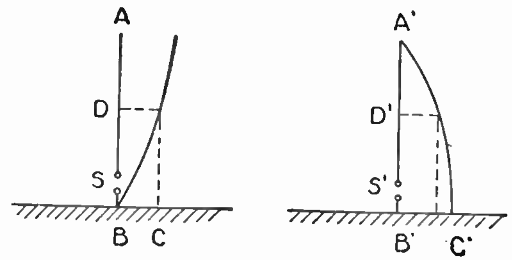


# The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

## THE ANTENNA [Continued]

IN THE usual case, the oscillator, or generator of high frequency oscillations, in the transmitting station, or the receiver at a receiving station, is located in the ground-lead near the ground. The reason for this, in the case of the receiver, is to obtain the greatest amount of current in the primary coil of the receiver, for it is obvious that there is no current flowing at all at the upper free end of the antenna, and the current has its maximum value at the point where the ground-lead is connected to the ground.




The antenna system, being a condenser, takes a charging current when an emf. is established in it. The antenna gradually charges up as the emf. increases from zero to maximum value during a quarter of a cycle. As the charge flows up to the free end of the antenna, the whole antenna gradually becomes charged, and since the current cannot jump off into space, the current must stop at the end. Therefore, the current value at the free end of the antenna must be zero. On the other hand, at the base of the antenna, where it is connected to the ground, the current has a relatively easy path away from the antenna, so that the greatest flow of current takes place at this point.

The distribution of voltage on the antenna is exactly the reverse. The highest voltage results where the concentration of the charge is greatest, so that since none of the charge flows away from the antenna at its upper free end, this must be the point where the voltage is greatest.

The current and voltage distribution in a simple antenna system can be very readily represented in a graphical fashion, by constructing a graph; the vertical axis or ordinate is taken as the antenna and the horizontal distance from it is equivalent to the value of the current or voltage at the particular point. Thus, the distance BC represents the value of the voltage at the height BD and the distance B'C' represents the value of the current at the height B'D'. It will be seen that the voltage is maximum at the free end and the current is maximum at the ground end.



# The EXPERIMENTER Radio Data Sheets

By Sylvan Harris

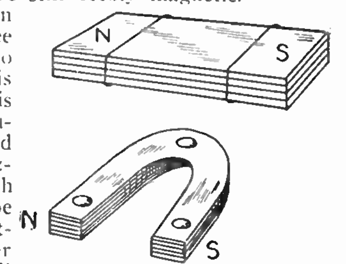
## MAGNETISM [Continued]

A CURRENT of electricity caused to circulate through a wire coiled about an iron core will cause this iron core to become magnetized. If the iron in the core is soft (that is, not tempered), it will be found that when the current is not flowing through the coil, the core will not be magnetized. On the other hand, if the core be of steel, and unmagnetized at first, it will be found to retain a great deal of its magnetism for a long period of time after the current has been turned on and off.

The combination of iron core and surrounding coil is called an electromagnet; it may be made in many shapes, for fulfilling various purposes. The figure shows a simple type of electromagnet, built in the form of a rectangular "U."

The magnetism of a permanent magnet is considerably reduced by heating the magnet. For instance, if the magnet be placed in boiling water, its magnetism will be found to be considerably lessened. It regains part of its magnetism, however, on cooling. On the other hand, chilling a magnet increases its strength. Cast iron ceases to be attracted by a magnet at about a red heat, or at a temperature of about 700 degrees Centrigrade. Cobalt retains its magnetism at the highest temperatures. Chromium ceases to be magnetic at about 500 degrees, and nickel at about 370 degrees Centigrade. The magnetic metals at high temperatures do not become diamagnetic, but are still feebly magnetic.

A magnet which has been magnetized to such a degree that it is impossible to further magnetize it, is termed "saturated." There is a case of what is called "super-saturation" often found immediately after magnetizing a bar or horseshoe, which soon disappears. A horseshoe magnet will support a greater weight immediately after being magnetized than it will after its armature has been once removed from its poles. Even soft iron, just after being magnetized, retains a slight amount of magnetism, which is termed "residual magnetism."




LAMINATED MAGNETS

The strength of a magnet is not the same as its lifting power. Its lifting power is an uncertain quantity, depending almost as much on the form and shape of the magnet as upon its degree of magnetization. The strength of a magnet is, therefore, measured by the force it will exert on a hypothetical *unit pole*, or, practically speaking, upon the force which it exerts at a distance upon other magnets.



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CUT ALONG PERFORATED LINES

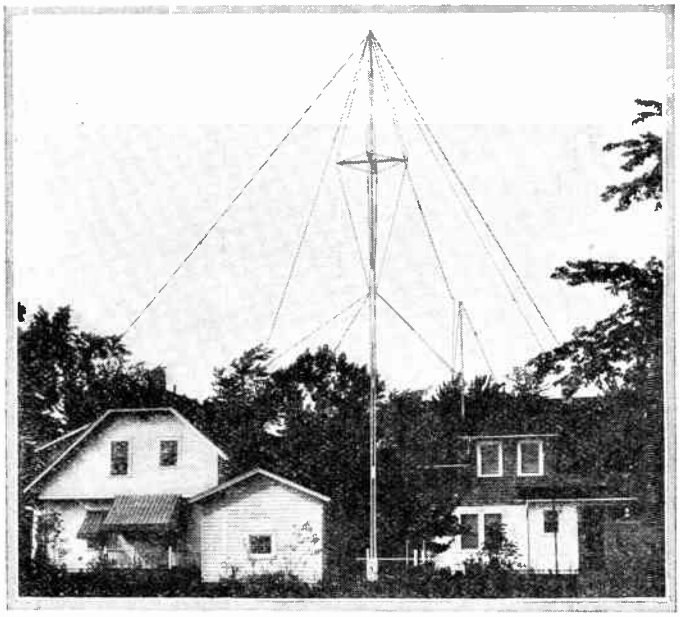
# Improving the Antenna

## By George S. Turner*

FOR the past few months the radio public has been devoting its entire thought and attention to the perfection of the receiver. Even such auxiliaries as power supply units and loud speakers have been considerably discussed, while the poor old antenna has been left out in the cold.

It is imperative to give the antenna some little attention. But, you ask, why should the writer be so bold as to attempt to add something *new* to countless articles on the defenseless antenna? You may think that I presume you do not know how to put up an aerial. You might say that the one you have is good enough. It receives signals. Yes, and so does the gutter pipe, the clothes line and the bed springs—but not efficiently.

Certainly, the average individual does know how to "put up" an antenna, but can he design and construct one to meet the requirements of the particular type of receiver he has installed, in the space nature has provided, in such a manner to insure selectivity and sensitivity? From what I have seen of thousands of antennae in this Ninth radio district, and particularly in the larger cities like Chicago, I venture to say the majority of them are "put up" with little, if any, forethought. Naturally, your receiver, no matter how good it is, nor how much it



**An excellent type of construction which embodies 20-foot sections of 2 by 4 securely bound together and well guyed. This particular installation happens to be owned by 2QS, who put it up single-handedly. Note especially the manner of guying.**

**It is not necessary to erect an expensive antenna mast either for reception or transmission.**

cost, cannot perform to its best advantage if it is not given proper encouragement and assistance. What I am getting at is: why not devote a little more effort toward making that antenna "low-loss," now that your receiver is "no-loss"?

With such an introduction, you may be expecting a complete and detailed discussion on the antenna. However, such is not necessary—you know the theory of operation of the antenna, as well as how to build one. Therefore, it is only my desire to offer a few timely suggestions and hints, leaving you to be the judge whether or not changes are necessary in the one you are now using.

### Average Antenna Too Long

To begin with, the average antenna is much too long, having been built two or three years ago, when receivers were not so sensitive, or, if recently, from information contained in some ancient periodical to the effect that "the longer the antenna, the better." This is far from true; nowadays, the length (over all—from the set to the furthest end) should be governed by the following:

1. Sensitivity of the receiver.
2. Proximity to a broadcast station.
3. Selectivity desired.
4. Number of wires.
5. Unobstructed location.

Consider, for illustration, the present-day three- to six-tube sets, having from one to three stages of radio frequency amplification. Usually, an antenna having an over-all length of 50 or 75 feet will give the most ambitious individual all the volume and distance desired. On the other hand, long antennae, upward of 150 feet in length, are only for use with crystal or one-tube sets.

Whenever a broadcast listener resides within a mile or two of a broadcast station, a long antenna is useless, unless this one station's signals are all that are desired, or unless methods of rejecting or by-passing these signals are used. For instance, it has been found that complaints have been made against a station regarding broad tuning when the complainant himself was at fault, because his antenna was entirely too long to be selective. Naturally, with a long antenna, it is rather difficult to keep the large pick-up from causing interference, especially if the circuit has a high decrement, which is usually the case. What, then, is the happy medium between a long and short antenna, taking into consideration the distance between the receiver and the broadcast station? That can best be determined by test, as each case will require special treatment.

### Improving Selectivity

In my effort to clear up in one evening a complaint such as I have outlined in the preceding paragraph, and not daring to brave the wire entanglements on an apartment roof after dark in order to chop off ten or twenty feet of aerial, I have been forced to resort to rather unusual measures to accomplish results. If it is impossible to reduce the physical length of an antenna to just balance the sensitivity of the receiver, we may obtain the same result by inserting capacity in series with the antenna—that is, providing you have a condenser available. It *always* happens, though, that the complaining party does not have spares, and it becomes necessary to manufacture one out of the material available.

Very satisfactory makeshifts have resulted from two tin pie-pans placed one inside the other, but separated electrically by varying thicknesses of paper to obtain various capacities (Fig. 1). Connect the antenna lead to one plate and make a connection from the other plate to the antenna connection on the receiver—or similarly, on the ground side

(*Continued on page* 241)

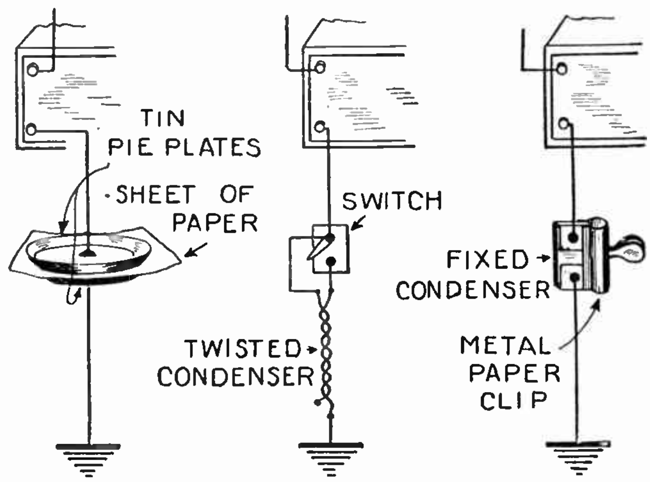
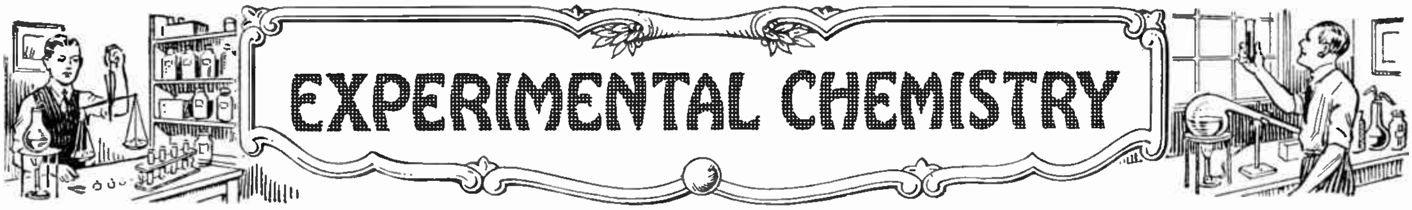



FIG. 1 FIG. 2 FIG. 3

**Various methods by which to change the effective length of the antenna. Fig. 1 shows a series condenser composed of two pie-pans separated by a sheet or two of paper; Fig. 2 shows the construction of a simple twisted-wire condenser and short-circuiting switch, while in Fig. 3 is shown the simple expedient of clamping a paper-clip on the metallic terminals of the fixed condenser.**

*Assistant Radio Inspector, Ninth District.

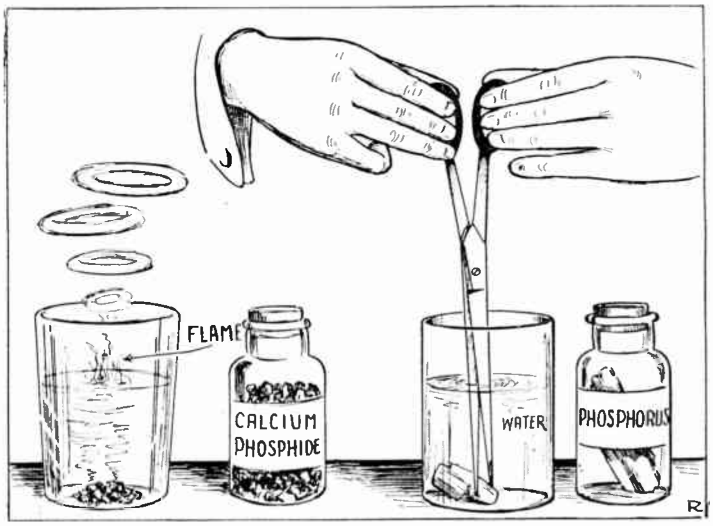


# EXPERIMENTAL CHEMISTRY

## Fire Under Water

By T. O'CONOR SLOANE, Ph. D.

PHOSPHORUS is an element having a very high affinity for oxygen, and not only does it possess this affinity, but combines with it at relatively low temperatures. Once the combustion becomes started, if there is sufficient oxygen, it will burn with much energy. This property of combining with oxygen at comparatively low temperatures is shown in several very interesting experiments, and the last one we speak of, if properly done, may rank as one of the most striking exhibits of chemical combinations. It is shown upon the cover of this issue.




Spontaneously inflammable phosphine, so-called, can be produced very simply by putting calcium phosphide into a glass of water. The figure to the right shows the cutting of phosphorus under water. It is so soft that it can be cut with the points of a scissors.

Phosphorus is a wax-like substance, which is sold in the shape of round "sticks," as they are called. It is often termed stick phosphorus; the pieces may be one-half inch or three-quarters of an inch in diameter and, perhaps, as long as one's finger. It is of the consistency of stiff wax and can be cut with a knife or scissors as readily as a paraffin candle. This must infallibly be done under water; if done in the air, there is almost a certainty of its catching fire. When it lights, it melts, so that a burn is an especially bad one, as the liquid spreads about over the skin and burns at the same time.

Before going on with the description of the experiment illustrated on our cover, it will be interesting to give a few simple experiments along the same line, which may serve to introduce it. The light which phosphorus gives, when exposed to the air on such conditions as not to catch fire, is termed phosphorescence. This is familiar to those who have had old-fashioned sulphur matches in their hand; these contained white phosphorous, and they could be moistened and rubbed upon the hands or fingers, whereupon the skin would glow, especially in the dark, with quite a ghastly effect.

Phosphorus is soluble in various liquids, among others, in olive oil, and if dissolved therein, will phosphoresce, or shine with a low intensity of light when exposed to the air. The hands, or even the face, may be smeared with the oil, so as to make the person present a very ghostly appearance in a dark room. The phosphorus in this mixture will not ignite in air. A bottle containing the olive oil solution constitutes what may be called a chemical flashlight; if uncorked and shaken, it will phosphoresce and emit a faint light. Then, when corked, the small amount of oxygen which may be in the bottle will soon be exhausted, and phosphorescence will cease.

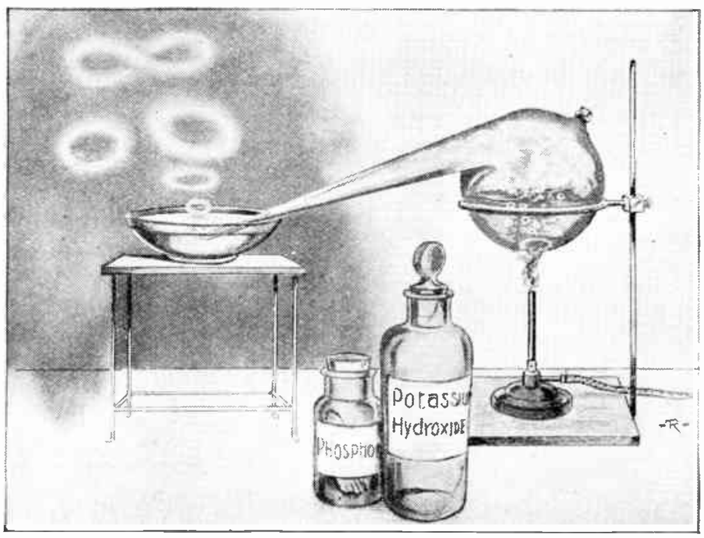
When phosphorus burns, it produces phosphoric oxide, a white solid, and of the various white smoke screens which have been proposed and used, this is one of the best. Phosphorus forms a gaseous compound with hydrogen, phosphine or phosphuretted hydrogen, whose formula is $PH_3$. This is often said to be spontaneously combustible and, as ordinarily produced, burns if it gets to the air. This ignition is due, however, not to itself, but to another compound of the same two elements, which is spontaneously combustible, and which acts as the match, or fuse, to ignite the other and principal gas. This compound is produced simultaneously with it.

To generate this gas, phosphorus is heated in a retort, or flask, with a solution of potassium or sodium hydroxide. As the water is heated, bubbles of this gas will escape from the phosphorus, rise through the liquid and ignite as they escape therefrom, provided there is air. If the solution of potassium hydroxide and the phosphorus is put into a retort or flask and heated, there will be a combustion, as the gas is generated, which will light, bubble by bubble, and may possibly break the flask or retort. Accordingly, before heating it, some ether may be poured into the generating vessel, flask or retort, or it may be filled with carbon dioxide gas. This will exclude the air, so that no combustion will take place within the vessel.

To conduct the experiment, the outlet of the retort, if such is used, is immersed in water in an evaporating dish or beaker; or, if the flask is used, it is corked and the end of a tube from the interior going through the cork is also dipped under water. Now, when the solution is heated, the first effect of the heat is to cause bubbles to pass through the water in the dish, which may be carbon dioxide gas or volatilized ether, according to which substance is used. Presently the phosphoretted hydrogen or phosphine will begin to come off and, as bubble after bubble escapes, it will burst into strong combustion, giving a bright light, producing "smoke rings" of phosphoric oxide. This is a classic old experiment. But it is one which the chemist uses over and over again to demonstrate the "light bearer," or, if we go to the Latin language, the "lucifer" of the elements, for phosphorus is from the Greek and has that exact signification, lucifer and phosphorus both meaning ethymologically "light bearer."

Even phosphorus in the air is liable to ignite spontaneously and the least friction will start it to burning. This is why it is always to be cut with knife or scissors under water, and great care must be taken that no fragments adhere to the hands when withdrawn from the water, or it may ignite and severe burns will result.

This spontaneous combustion is illustrated by a very interesting experiment which has one bad feature, that, owing to the fact that carbon bisulphide is never quite pure, a very disagreeable odor is produced. Phosphorus dissolves with great readiness in this liquid. A solution is made by simple mixture and a piece of paper is saturated with it; it may




Here the classic experiment of the production of phosphine or phosphuretted hydrogen by the action of sodium or potassium hydroxide solution upon phosphorus is shown. Before heating the solution the retort must be filled with illuminating gas or hydrogen gas or a little ether may be poured into it, or carbon dioxide gas may be introduced. The idea is to expel air so that there will be no explosion within the retort.


**A paper flag is dipped into a solution of phosphorus in carbon bisulphide, held in the air and perhaps waved about a little, is soon ignited and burns with a slow flame.**

be attached to a stick like a flag, for on no account should it be held in the hand, exposed to the air and perhaps waved about a little, the carbon bisulphide will rapidly evaporate, being very volatile, and finely divided phosphorus will be left on the paper and will light spontaneously and the paper will burst into flame.

Phosphorus has one peculiarity; the product of its combustion, phosphoric acid, tends to make any object to which it is applied non-combustible, or at least difficultly combustible. So that, while it ignites easily, as on the paper, its action is, to a certain extent, to make the paper non-combustible, so that flames will not be as impressive as might be anticipated.

One of the most showy experiments in chemistry is the burning of phosphorus under water. A piece of phosphorus is put into water and the water is heated pretty well up to the burning point; the phosphorus will melt into a globule, flattened down naturally by its own weight. If now a stream of oxygen is brought in contact with the melted phosphorus beneath the water, it will oxidize and burn, giving a considerable amount of light.

Potassium chlorate is one of the chemicals much used, especially by students, for the manufacture of oxygen. It contains a large percentage of oxygen, whose combination with the potassium and chlorine is so weak that a rather mild heating, especially in the presence of a catalyst such as manganese binoxide will cause it to evolve oxygen at a very moderate temperature. If it is treated with concentrated sulphuric acid, a very violent reaction takes place, which seems almost to verge on an explosion, so much so that, from considerations of safety, it should never be done but on the very small scale, using, perhaps, as much of the potassium chlorate as would lie on the point of a penknife.

The specific gravity of sulphuric acid is nearly double that of water, so that there is no trouble in having it lie beneath a layer of water. This is very readily done by putting water into a vessel and pouring sulphuric acid through a straight thistle tube into the very bottom of the vessel. The thistle tube must go straight down until it touches the glass. If this is done, the sulphuric acid will lift, or float, the water above its surface, the latter forming a supernatant layer, and while mixing, of course, goes on at the surface of contact, the mixing is very slow.

To produce fire under water in what we may call a self-contained experiment, without using any extraneous oxygen, we proceed as follows: Some water is poured into a flask, so as to fill it about one-third full, and the flask should by all means be a round-bottomed one. A flask eight or ten inches in diameter is none too large, while, for private satisfaction and inspection, a test tube can be used.

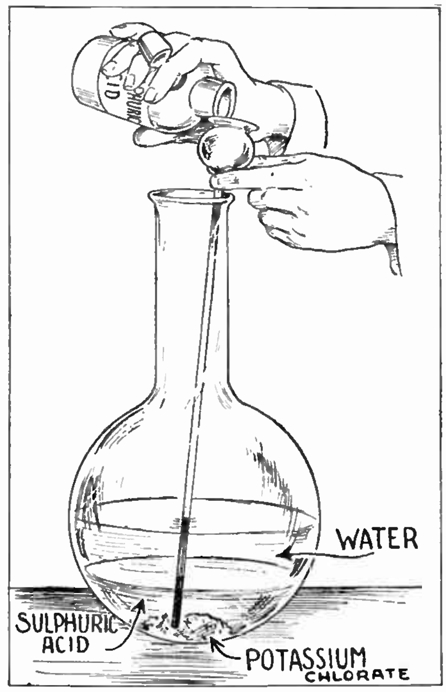
The object of using a round-bottomed flask is, because of its shape, the sulphuric acid will keep distributed over a limited area and will not spread about, and this is quite an important element in the work.

After introducing the water, a little pile of potassium chlorate crystals is to be made upon the bottom; if the crystals are dropped into the water they will sink rapidly and will lie quietly, going but little into solution. It is essential to keep the flask as undisturbed as possible. Next comes the phosphorus. Put the stick of phosphorus in a basin of water, or in a beaker, or even in a tumbler, keeping it always as far as possible under the surface of water. It need never be exposed except for a few seconds to the air. With a scissors, cut off a little piece; if it is as big as two or three peas it will be sufficient for quite a display. This sinks at once, when put into the flask, and lies upon the potassium chlorate.

Now comes the part of the experiment on which the degree of success depends, for however badly done, the experiment is bound to succeed to some extent. But it is worth while doing well. The thistle tube is placed in the flask, reaching down into the very bottom, as described above. Concentrated sulphuric acid, there is no need of it being chemically pure, is now poured in very carefully through the thistle tube, the idea being to avoid disturbance of the water, so that the sulphuric acid will lie at the bottom, under the water, with a sharp plane of separation between water and acid. If a straight thistle tube is used, there will be no trouble in doing this; if one with a safety bend in it is used, the acid will first fill the little trap in the tube and then will enter suddenly, with the effect of disturbing the separating plane, or surface, between acid and water. The whole point is to get the acid below the water as quietly as possible, and this is to be done by letting it trickle slowly down through the straight thistle tube, so as to secure the sharp, or nearly sharp, division between the two liquids.

The acid now attacks at once the potassium chlorate, setting free chloric acid, and a violent combustion of the phosphorus begins. It glows under the acid, particles of fire fly up through the water, little bits of phosphorus, perhaps, will stick to the glass, and what is one of the most showy demonstrations in chemistry ensues. To make it more showy, some calcium phosphide may be dropped into the flask; this, perhaps, will not only burn, but may, even in the presence of the potassium chlorate and sulphuric acid, generate spontaneously combustible phosphoretted hydrogen, which will ignite on the surface of the water.

(*Continued on page* 246)




**The experiment shown upon the cover page of this magazine is illustrated above. Concentrated sulphuric acid is being poured through a straight thistle tube upon a little pile of potassium chlorate crystals surrounding a piece of phosphorus and covered with water. The phosphorus burns beneath the fluid.**

# Automatic Syphon

SOME time ago, we published a description of a very curious syphon of the self-starting order, and which we found on trial to have the faculty of charging itself.

We illustrate today another syphon, also of the self-charging type, which is made for laboratory use especially, and which is sold in London.

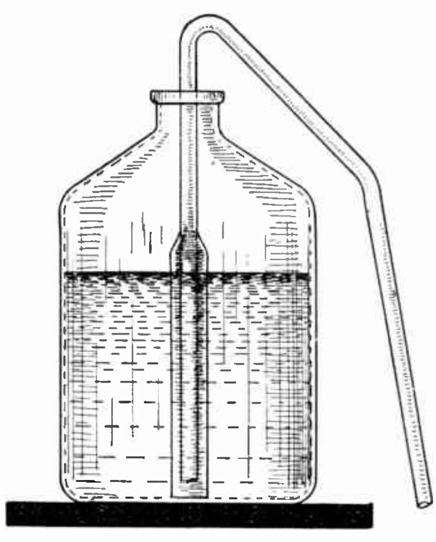
The construction is quite simple; to the straight limb of the syphon, the one which enters the bottle or other vessel from which liquid is to be syphoned, there is attached a larger tube, open at the lower end, and melted securely to the syphon tube in its upper end, so that it is concentric with the syphon, and looks something like an inverted test tube.

When this is put into a sufficient depth of water, air is compressed in the upper part of the outer tube and, to relieve itself, forces water up into the syphon tube. The two tubes are so proportioned that the water rises in the syphon tube beyond the bend, so that it starts to operate without the need of suction.

Those of our readers who are disposed to try it for themselves can improvise one by using a straight piece of tubing of adequate diameter fitted to the syphon tube by a perforated cork at its upper end, instead of the two outer tubes soldered to the inner one, which requires a certain amount of skill to execute. This, it will be seen, reproduces the commercial one shown in the illustration.

Various forms of syphons have been devised in which the charging is effected without the absolutely dangerous suction principle. Of course, suction is perfectly safe if the liquid is water, but it is quite impracticable when dealing with acid and poisonous or corrosive solutions. The one we illustrate is extremely simple and as an indication of its merit it has been put on the market as a commercial article, as just stated.

In our previous issues other syphoning arrangements have been shown.



**A self-charging syphon. The air pressure in the concentric tube at one end forces the liquid up so as to start it.**

# New Chemical Experiments

By RAYMOND B. WAILES

GIVEN a mixture of iron filings and sulphur, many of the younger generation would be stumped if he were asked to separate the bits of iron from the bits of sulphur. Probably after a time the thought of magnetism would be recalled and with the assistance of a magnet, stroking it through

**Iron filings and sulphur when mixed, however intimately, are readily separated by a magnet which draws the iron filings completely out of the mixture. When melted together at red heat they form iron sulphide and cannot be separated by the magnet.**

the mixture, all of the iron could be separated from the yellow particles of sulphur.

It is often but a step to convert a mechanical mixture into a chemical compound. To do this all that is necessary is to heat the mixture of iron filings and sulphur in a test tube. First the sulphur will melt, burn, and then will combine chemically with the iron filings, forming iron sulphide. The "burning" of the iron in the sulphur can be vividly seen when this heating is carried out, a bright glow spreading through the mass. The resulting product is a chemical compound, and no magnet in the world can now separate the iron from the sulphur.

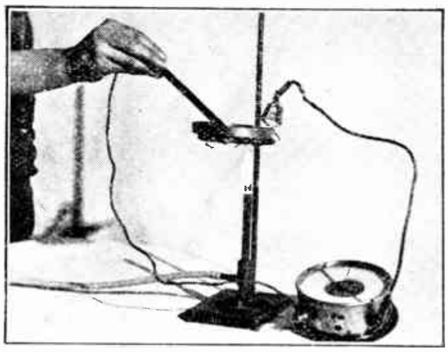
A striking experiment which shows how some substances change in volume when cooled can be performed with a test tube and some powdered potassium bichromate. The potassium bichromate or bichromate of potash, as it is frequently called, is cautiously heated in a test tube until it melts. A strip

**Potassium bichromate is melted in a test tube; it is allowed to cool, begins to crackle, expands as it solidifies, the tube flies apart and the potassium bichromate remains a solid mass.**

of paper wrapped about the upper end of the tube will act as a handle for holding the tube if a test tube holder is not available. When the substances has melted, set the tube aside to cool. As this lower temperature is reached, a crackling noise will be heard in the tube which will grow louder and louder and more frequent. Soon the whole tube will fly apart and the solidified potassium bichromate will be found left behind in the form of a pillar of minute crystals. Further examination will show that the pillar is larger in diameter than the test tube. The one draw-back to this experiment is that a perfectly good test tube is broken. This should not deter the experimenter from trying the experiment, however; the potassium bichromate can be used for other purposes as it has not undergone any chemical change.

How the direct oxidation of carbon can produce electricity is clearly shown if a galvanometer or other fairly sensitive electrical indicating instrument is available.

A lid of a coffee or other can is used as the battery cell in this experiment. It should be partially filled with potassium nitrate or sodium nitrate and heated with the Bunsen burner until the nitrate melts. A high temperature is not needed. A battery clip is now attached to the tin and led to one terminal of a milliammeter or galvanometer. The other terminal of the instrument is connected by means of a wire to a rod of carbon which can be conveniently taken from either an "A" or a "B" "radio" battery. If the carbon rod is now dipped into the molten nitrate a



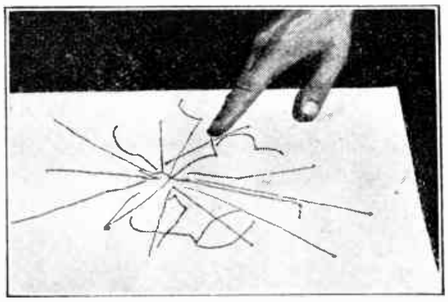
**A tin cover containing sodium nitrate is connected to one pole of a milliammeter. The sodium nitrate is melted by a Bunsen burner. A wire from the other terminal of the measuring instrument is wrapped around the end of a rod of carbon and this is held in the melted nitrate, producing a current of electricity.**

generous swing of the indicating hand of the instrument will be perceived, showing that an electric current is being produced. This current is due to the oxidizing action of the nitrate upon the carbon rod, producing a chemical reaction and developing an electric current.

A curious effect, much resembling a huge spider, can be created by allowing molten antimony or bismuth metal to fall from a height of several feet upon a sheet of white paper. The molten globules will chemically combine with the oxygen as they fall through the air and when they strike the paper will break up and go shooting helter-skelter in all directions radiating from the spot where they initially struck the paper. Their track will be clearly left behind as a trail of oxide of the metal used. The metals can be heated in a test tube. Either or both of them can be used. At the end of the experiment the particles of metal and oxide can be collected and placed in a bottle marked "metallic antimony and antimony oxide," if antimony metal was used.

Some substances when dissolved in water produce a large amount of heat. Sodium hydroxide is an example of this. Other substances absorb a large amount of heat or "produce a large amount of coldness." Potassium nitrate and ammonium nitrate are examples of the latter. Gases dissolved in water usually produce varying quantities of heat. Hydrochloric acid gas is a substance having this property.

To show the effect of the heat produced when hydrochloric acid gas dissolves in water to form hydrochloric acid is very simple. Tie a layer or two of cotton rag about the bulb of a thermometer. An engraved stem, chemical thermometer is ideal for this purpose, although a common household or bath thermometer can be used. Now wet the rag and drain off the surplus water. Place the bulb with its surrounding damp

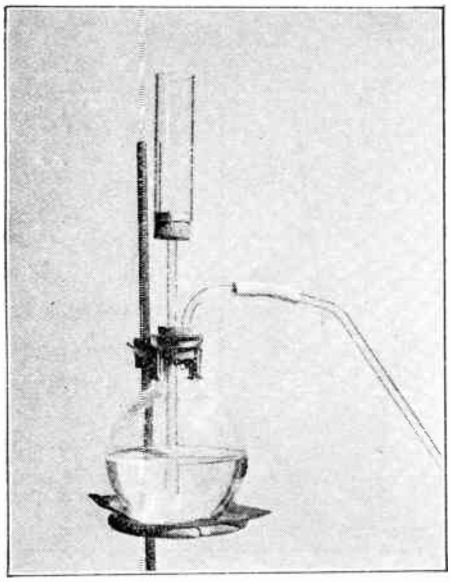


**An attempt to show the path pursued by globules of melted antimony or bismuth, when dropped upon a board or sheet of paper.**

rag above the surface of strong hydrochloric acid in a bottle. Such acid gives off fumes of hydrochloric acid gas when exposed to the air. This gas will be absorbed by the damp rag and will dissolve in the water upon the rag, producing heat which will be indicated by a rise in the mercury of the thermometer. The rise is often ten degrees or more. A strip of blue litmus paper applied to the moistened rag will immediately turn red, showing that the hydrochloric acid gas has really been absorbed by the water, forming a solution of hydrochloric acid. Strong acid must be used.

A cheap source of hydrogen gas is useful in many chemical experiments. Many chemical experimenters have often used zinc metal and a dilute acid for the generation of this gas. A very cheap method of producing this gas is by heating a solution of sodium hydroxide or lye water with pieces of metallic aluminum. The aluminum can be cut from a discarded kitchen pot or pan. The sodium hydroxide should be dissolved in water, making about a ten per cent. solution (10 grams dissolved in water and this solution diluted with water to 100 cc.) Commercial lye as sold in cans for household use can be used very well in place of the sodium hydroxide. Its small percentage of carbonate will not prevent the production of hydrogen gas.


**A thermometer bulb surrounded by a wet rag is supported above the surface of hydrochloric acid. The absorption of the gaseous hydrochloric acid hy the water in the rag produces heat, which is shown by the thermometer.**



An easily made thistle or funnel tube, no glass blowing being required. The thistle tube is shown in use in an apparatus for generating hydrogen by heating aluminum and sodium hydroxide solution.

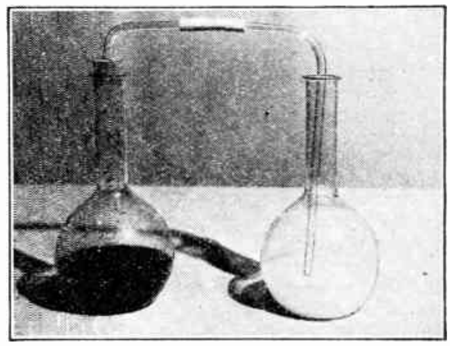
A round-bottomed flask is used, because the caustic solution has to be heated in contact with the aluminum strips. When such solutions are heated, bumping of the liquid against the walls of the flask occurs, and this is often strong enough to break the flask, especially if it be a flat-bottomed one. A round-bottomed Pyrex flask is ideal.

An easily made thistle tube or funnel is also shown. It consists of a 3- or 4-inch length of glass tubing having a diameter of about an inch or more. It is fitted by means of a single hole cork to a glass tube which extends into the gas generating flask. The alkaline solution is poured into this improvised thistle tube. The gas escapes from the right-hand exit tube. If this gas delivery tube plugs up, the gas being generated will back the solution up into the funnel, which thus acts as a safety device.

Sugar is a carbohydrate, a term applied to a host of substances having carbon hydrogen and oxygen as their elements. They must not be confused with hydrocarbons, which contain no oxygen.

Carbon dioxide gas can be made from sugar by treating it with strong sulphuric acid. The sugar turns black, swells up and gives off carbon dioxide gas, which when passed through lime water produces a white precipitate of calcium carbonate, or "precipitated chalk." Two flasks and two pieces of L-shaped tubing are all that is necessary for setting up this interesting experiment. Dilute sulphuric acid can also be used providing that it has some potassium bichromate crystals in it, thus forming chromic acid.

A suitable gas-generating flask for aluminum and caustic alkali used in the making of hydrogen gas is shown in one of the photographs.

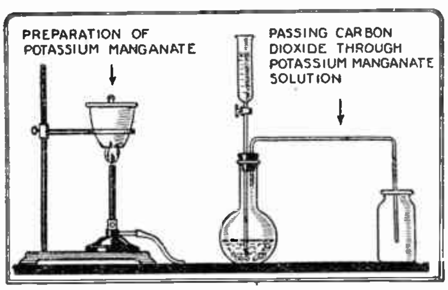


The decomposition of sugar by sulphuric acid with evolution of carbon dioxide precipitating calcium carbonate in the right-hand flask.

# Experiments with Manganates and Permanganates

## By Eugene W. Blank

MANGANESE is a metal which forms a great variety of compounds. It forms two main classes of salts, the manganous compounds and the manganic compounds. In the manganous compounds




The left-hand figure shows the production of sodium manganate by heating sodium or potassium hydroxide with manganese binoxide. On the right is shown the production of potassium permanganate by passing carbon dioxide gas through a solution of manganate.

the metal is bivalent and in the manganic compounds the metal is trivalent.

Place a mixture of manganese dioxide, potassium hydroxide and a small quantity of some oxidizing agent such as potassium nitrate or chlorate in a small crucible and heat in the Bunsen flame. The fused mass soon turns green and then the heat can be removed. The reaction is as follows:

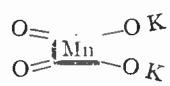
$$2MnO_2 + 4KOH + O_2 \rightarrow 2K_2MnO_4 + 2H_2O$$

Sodium manganate can be made in the same way, by using sodium hydroxide in place of potassium hydroxide. The green solution of potassium manganate obtained as above is unstable and soon passes into potassium permanganate, as is shown by the following reaction:

$$3K_2MnO_4 + 2H_2O \rightarrow 2KMnO_4 + 4KOH + MnO_2$$

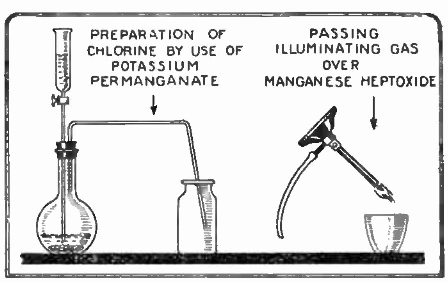
This change can be made more rapidly by passing a current of carbon dioxide gas through the solution.

A solution of potassium manganate can also be made by heating a solution of potassium permanganate with a solution of potassium hydroxide. By analogous constitution, manganese appears to be sexivalent in the manganates, and so the structural formula for potassium permanganate appears as follows:




The potassium permanganate, which the reactions of the manganates give rise to, is a dark purple crystalline compound. Its solutions have a beautiful red color and in many of the reactions of the manganates the green solution of the manganate gradually changes to a purple color. On account of this change in color, Scheele called potassium manganate chameleon mineral.

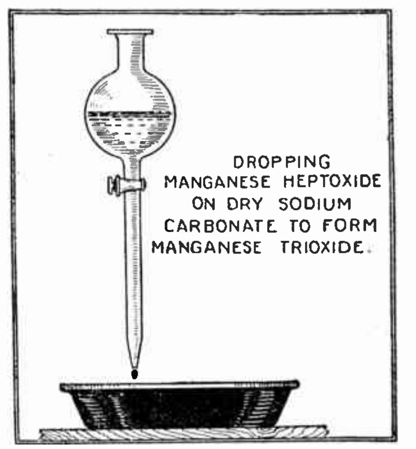
Potassium permanganate is a salt of permanganic acid, $HMnO_4$. To prepare permanganic acid, we need barium permanganate, but since the average experimenter may not have this compound on his shelf, we will start with potassium permanganate and prepare some barium permanganate. Add a hot solution of silver nitrate to an equally hot solution of potassium permanganate and cool the mixture by placing the beaker or retaining vessel in a pan of cold water. Sil-




Potassium permanganate treated with hydrochloric acid gives a convenient method of obtaining chlorine gas. It is shown on the left. On the right is shown the experiment in passing gas from the Bunsen burner over the surface of manganese heptoxide.

ver permanganate will separate and this should be filtered off and dissolved in water. Now, to the solution of silver permanganate, add a solution of barium chloride and filter off the silver chloride. The filtrate is a solution of barium permanganate. To it add sufficient sulphuric acid to precipitate all the barium and then filter off the precipitate of barium sulphate. The filtrate is a violet solution of permanganic acid. The acid is a very powerful oxidizing agent, as is the salt potassium permanganate.

To show the oxidizing power of potassium permanganate, place a small amount of the salt on a metal plate and allow a drop of




The reduction of the highest oxide of manganese by the action of sodium carbonate.

glycerine to fall on the mass. A rather violent reaction ensues and the glycerine in a great many cases takes fire and burns.

A mixture of sulphur and potassium permanganate is violently explosive.

The oxidizing power of potassium permanganate is also shown when it is used in chlorine making. In this particular case, the permanganate oxidizes the hydrochloric acid to water and chlorine gas.

$$2KMnO_4 + 16HCl \rightarrow 8H_2O + 2KCl + 2MnCl_2 + 5Cl_2$$

To prepare chlorine by this reaction, place some potassium permanganate in a flask and allow hydrochloric acid to slowly drop upon the salt. Chlorine is given off in abundance.

Potassium permanganate can also oxidize sulphurous acid to sulphuric acid and, in so doing, will lose its characteristic color. Hence, by passing a stream of sulphur dioxide gas through a solution of potassium permanganate, the solution will gradually lose its red, or violet, color and the sulphurous acid in solution will be oxidized to sulphuric acid.

If we place some potassium permanganate

(*Continued on page* 240)

# Mirrors from Chemical Convex Covers

By Earle R. Caley, B.Sc., M.Sc.

MANY experiments in physics require the use of concave and convex mirrors, which are generally expensive to purchase. Very satisfactory substitutes can be made from the ordinary chemical "watch glasses" or convex covers, which only cost a few cents apiece. The process is detailed in the following paragraphs.

The first step is the selection of the watch glasses. There are two makes sold by scientific supply houses. One is a heavy thick watch glass made from a green-colored glass. The other type is made from colorless glass and is thinner. Only the latter kind should be used for making these mirrors. Watch glasses can be purchased in many different sizes varying from small ones about an inch in diameter to large glasses ten inches across. It is an easier matter to silver the smaller glasses, but with care even the larger sizes can be very successfully coated. Glasses of an even, uniform appearance, free from defects, are necessary.

The first step is the proper cleaning of the glasses; they must be *perfectly* clean and free from the slightest traces of grease. The "cleaning solution" is made by dissolving a few crystals of potassium bichromate in one hundred cubic centimeters of sulphuric acid. The glass is immersed in this solution for ten minutes and next is rinsed with distilled water. It is placed in a ten per cent. solution of sodium hydroxide for another ten minutes. The object is then thoroughly rinsed again with distilled water, and then placed in distilled water until ready for the silvering operation. The glasses should never be handled by touching the surfaces, as this leaves grease marks that show later. Only the edges should be touched in transferring the glasses.

After being cleaned, the watch glasses are ready for silvering. Three solutions are required for this purpose. Their composition is as follows:

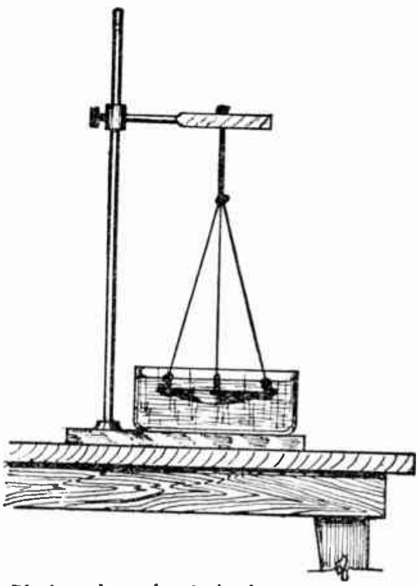
*Solution No. 1*

| | |
|---|---|
| Silver nitrate | 2 grams |
| Ammonium nitrate | 3 grams |
| Distilled water | 100 c.c. |

*Solution No. 2*

| | |
|---|---|
| White granulated sugar | 5 grams |
| Tartaric acid | 1 gram |
| Distilled water | 50 c.c. |

This solution is boiled until the solids have gone into solution, ten c.c. of denatured alcohol is then added and enough distilled water added to make the volume 100 c.c.



Plating by chemical decomposition upon glass; the familiar "watch glass" of the chemist is used so as to get a convex or concave mirror as required.

*Solution No. 3*

| | |
|---|---|
| Potassium hydroxide | 10 grams |
| Distilled water | 100 c.c. |

The three solutions are separately prepared and kept in separate bottles until ready for use. Solution No. 1 must be kept in a dark place or in a dark colored bottle.

The apparatus required for the silvering process is shown in Fig. 1. The watch glass is suspended from a ring stand by three strings having glass hooks at the ends. These hooks are easily fastened from small pieces of glass rod. A glass dish may be used to hold the silvering solution, as shown, but a porcelain vessel may be used.

The operation of silvering is conducted as follows: The clean watch glass is taken from the distilled water by means of the hook arrangement and suspended in position over the flat dish. About five minutes should be allowed after this to let the excess water drain off. The dish is then filled with the silvering solutions, which are mixed in the following manner: Equal parts of solution No. 2 and solution No. 3 are first mixed together in the dish. Enough of solution No. 1 is then added to the mixed solutions to double the volume. This measuring should be accurately done by means of a glass graduate. The silvering then commences as soon as the last solution is added. The process is allowed to go on until a firm, dark coat of silver entirely covers the watch glass. The speed of the reduction depends somewhat upon the temperature, but usually thirty minutes is all that is required. The glass is then removed and rinsed with water. In this manner the entire watch glass is covered with a layer of deposited silver, which at this stage resembles almost anything except a

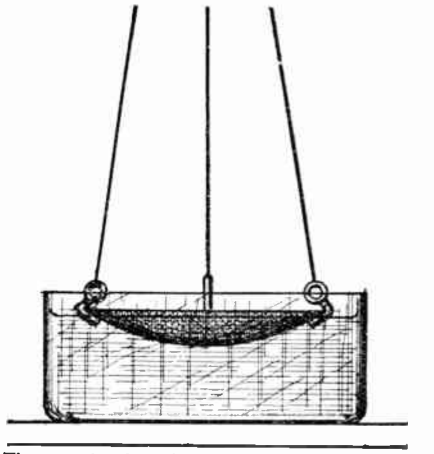
The watch glass plated on both sides is filled with nitric acid which in a few seconds dissolves the coating on the concave side, giving a concave mirror.

shining glass mirror. The side next to the glass, however, has the usual mirror surface. The next step is to remove the excess silver from one side of the glass or the other, depending upon whether a concave or convex mirror is desired.

The silver is removed by means of a dilute solution of nitric acid. If a concave mirror is desired the process is very simple, as shown in Fig. 2. In this case, the concave side of the silvered mirror is filled up with dilute nitric acid and allowed to stand until all the silver from this side has dissolved off. Fig. 3 shows the arrangement used for dissolving off the silver from the other side in order to form a convex mirror. In either case, as soon as the excess silver has been completely removed, the mirror is washed thoroughly with water and is allowed to dry. In this manner are formed very excellent mirrors with fine reflecting surfaces.

In order to preserve the silvering, and to prevent it from being knocked off, a coating of ordinary shellac should be applied to the back of the coating as soon as the mirror is thoroughly dry. If the process is carefully followed as detailed above, little trouble will be experienced in making these mirrors. If the silver fails to adhere to the glass, the cleaning operation was poorly done and the process must then be repeated. If the film appears brown and can be seen through, the time allowed for silvering must be lengthened. These troubles will not appear, however, if the process is correctly carried out.

Mirrors of this kind can be used for many purposes. They are indispensable in carrying out experiments with light such as detailed in the ordinary textbooks on this science. They can be used as reflecting surfaces for home-made searchlights and for numerous other purposes that will readily suggest themselves to the experimenter.



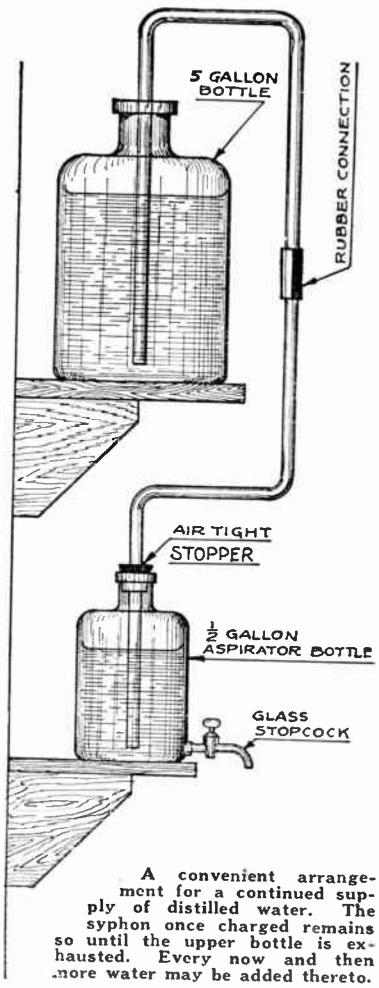
The watch glass is suspended in a vessel of nitric acid so that its lower surface is covered therewith. This dissolves off the silver on the convex side and gives a convex mirror.

# Distilled Water Container

THIS represents a device for the delivery of distilled water. It eliminates all the usual rubber tubes and glass syphons with the very unsatisfactory tube clamps and stopcocks, etc., and also gives pure water as the operator only touches the glass tap when turning it open.

Any convenient size of glass tubing can be used and of course any size bottles. The distance between the shelves is best at some 20 inches as shown. The aspirator bottle should not be full, but should be as indicated. If full it is impossible to keep the stopper in.

*Contributed by Harry L. Elder.*




A convenient arrangement for a continued supply of distilled water. The syphon once charged remains so until the upper bottle is exhausted. Every now and then more water may be added thereto.

# Odd Chemical Experiments

## By EUGENE W. BLANK

### A Chemical Hot Water Bottle

THE contents of a chemical hot water bottle, for use in automobiles in winter and similar purposes, consist of one part sodium acetate and nine parts of sodium hyposulphite. Put the mixture in a flat-sided bottle and place the bottle in a pan of hot water. After it has become well heated, remove and dry the outside surface with a towel. The bottle will continue to give off heat for approximately twelve hours.

### Ammonium Bichromate

Place a few crystals of ammonium bichromate on an iron plate and gently heat with a Bunsen burner. The crystals deflagrate with beautiful scintillations and green chromium oxide is left as a residue. The reaction is as follows:

$$(NH_4)_2 Cr_2 O_7 \rightarrow Cr_2 O_3 + 4H_2O + N_2$$

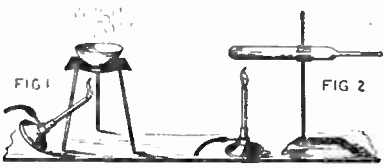



**Fig. 1 shows a beautiful experiment with ammonium bichromate; on simple heating it deflagrates brilliantly. Fig. 2 shows the preparation of pyrophoric lead by heating lead tartrate in a sealed glass tube.**

### Pyrophoric Lead

Mix solutions of lead nitrate and tartaric acid and filter off the precipitate of lead tartrate. Wash and dry at room temperature. When the precipitate has been thoroughly dried, place it in a tube with a thin, long neck. By gently heating the lead tartrate it decomposes, and finely divided lead is left as a residue. When the reaction is at an end, that is, when all the gas has been evolved, seal the end of the tube and let it cool. If the cold powder be allowed to fall through the air, it will inflame and oxide of lead will be formed.

### Iodine and Zinc Dust

Mix some zinc dust with a small amount of iodine crystals and place the mixture in a small evaporating dish. No reaction appears to take place between the zinc dust and the iodine crystals, but if a few drops of water are added to the mixture a violent reaction will take place.

### Preparation of Oxygen From Calcium Hypochlorite

Make a thin paste of calcium hypochlorite, or bleaching powder, with water and to it add a solution of some cobalt salt, as cobalt nitrate. Oxygen is slowly evolved.

### Potassium Iodate

Potassium iodate can be made by making a hot solution of potassium chlorate and slowly adding to it some dilute nitric acid. Also add a small quantity of iodine crystals and keep the mixture warm. Chlorine is liberated and the iodine passes into solution. Allow the clear solution to cool and collect the crystals of potassium iodate as they separate.

### Zinc Ferricyanide

Mix solutions of zinc sulphate and potassium ferricyanide and collect the precipitate on a filter. Wash well and dry in an oven or on a water bath. When a small amount of the precipitate is gently heated, it turns green, and if allowed to cool, it resumes its original color.

### Fulminating Gold

Prepare a solution of gold chloride and carefully add to it some ammonium hydroxide. A pale, yellow precipitate will separate and this should be filtered off. Leave it to dry at room temperature, and when it is dry, ignite small portions of it. As each particle of the precipitate decomposes, it emits a loud report. Do this with very small portions, as it may produce a dangerous explosion.

### Chromium Sesquioxide

Chromium sesquioxide is a dark green powder used as a pigment. It can be pre-

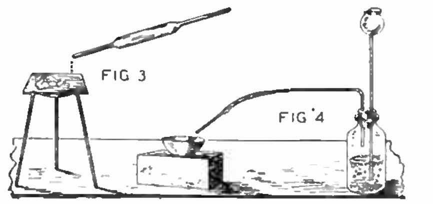



**Fig. 3. By adding a few drops of water to a mixture of zinc dust and iodine crystals, a violent reaction is produced. Fig. 4. Passing a strong current of hydrosulphuric acid gas over lead peroxide, an energetic oxidation takes place, perhaps igniting the gas.**

pared by heating ammonium bichromate, as described above, or by heating a mixture of ammonium chloride and potassium dichromate. Wash the compound to get rid of the potassium chloride formed in the reaction and dry the powder. Chromium oxide, when in an extremely fine state of subdivision, appears to be red in color. This phenomena can be shown by mixing some zinc oxide with a small portion of chromium oxide and heating to a high temperature, preferably in an oxidizing blowpipe flame. The mass will acquire a pink to red color instead of the characteristic green color.

### Action of Hydrogen Sulphide on Lead Peroxide

Construct a generator that will furnish a strong current of hydrogen sulphide; a Kipp generator will serve very well. Place some lead peroxide in a small evaporating dish and allow the hydrogen sulphide gas to blow upon it. The hydrogen sulphide will vigorously react with the peroxide and, in doing so, ignite. Needless to say, it is best to perform this experiment outdoors.

### Action of Metallic Magnesium on Ammonium Salts

Metallic magnesium reacts with solutions of ammonium salts, liberating hydrogen and forming double salts. Make a saturated solution of ammonium chloride and to it add some magnesium. It rapidly dissolves and evolves hydrogen.

# Making Pigments in the Laboratory

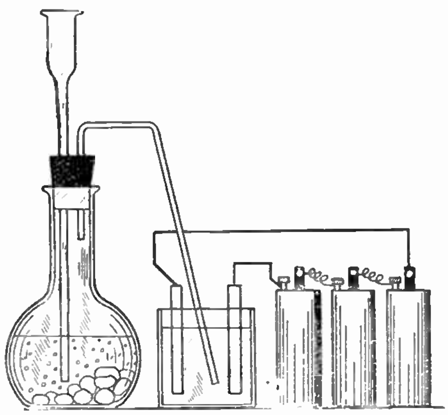
## By EUGENE W. BLANK

PIGMENTS are substances which, when mixed with a suitable oil, are used for painting. The preparation of several pigments is given below. By grinding them and mixing with linseed oil small quantities of paint can be made.

White lead, which is used in paints, is a basic lead carbonate of the following general composition $Pb(OH)_2.2PbCO_3$. The Dutch process for the manufacture of this pigment has been in use for over three hundred years and consists of allowing the vapors of vinegar and carbon dioxide, the latter evolved from moist tan bark or other substance, to act slowly upon large surfaces of lead. Several weeks are usually required to complete the action, so electrolytic processes have been proposed.

To make the pigment by electrolysis arrange the apparatus as shown and in the jar place a solution made by dissolving 10 grams of sodium nitrate in every 100 cc. of water. Connect the lead plates to a direct current, and while the current is passing allow a stream of carbon dioxide gas to bubble through the solution. The carbon dioxide can be generated by the action of dilute hydrochloric acid upon marble chips. As the gas bubbles through the solution lead carbonate is precipitated and falls to the bottom of the jar. Now stop the passage of the carbon dioxide and allow the current to run for a few minutes. The white pigment can now be collected on a filter and dried.

Lead paints have the disadvantage of turn-



**A most interesting combination of chemistry and electricity; making white lead, one of the great pigments of industry. Carbon dioxide gas is passed through the electrolyte; lead plates are used as electrodes and a current is passed.**

ing black in some cases when exposed to an impure atmosphere on account of the minute traces of hydrogen sulphide present in the atmosphere.

Lithopone is a pigment extensively used in the manufacture of enamel and marine paints. It can be made by mixing solutions of barium sulphide and zinc sulphate. The precipitate formed consists of barium sulphate and zinc sulphide, both perfectly white and pulverulent. The precipitate is filtered off and washed and dried. It is then placed in a small crucible and heated to dull redness. While still hot pour it out into cold water. Filter and dry.

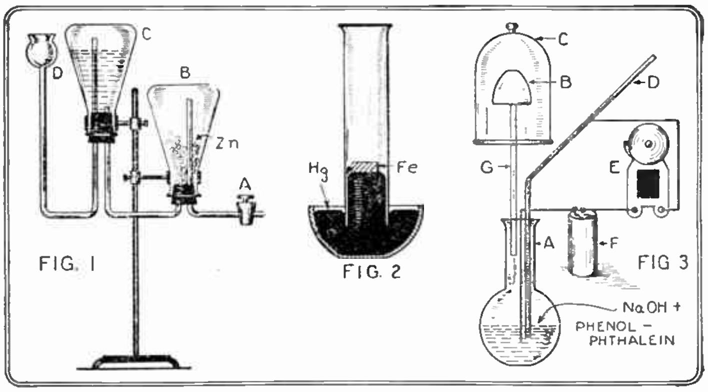
Chromium sesquioxide is a grass green pigment used in the manufacture of green paints. It can be obtained by fusing a mixture of three parts boric acid to one of potassium dichromate. The mass swells and becomes a fine bright green color.

A yellow pigment can be made by adding to a solution of lead nitrate a solution of potassium dichromate. The yellow compound is lead chromate and is known as chrome yellow.

The combination of a color and aluminum hydroxide is called a lake; lakes are used in dyeing and in printing calico. To prepare various colored lakes make a solution of a dye of the color which you wish the lake to be. Add a solution of aluminum sulphate and then slowly add ammonium hydroxide and allow to stand in a quiet place. When the ammonium hydroxide is added to the solution of aluminum sulphate, aluminum hydroxide is precipitated and when this settles it carries down the coloring matter, leaving the supernatant liquid clear. The colored mass formed is termed a lake.

# Interesting Properties of Hydrogen

By J. G. Schumacher, A.B., M. S.




**In Fig. 1 is shown a very interesting apparatus for generating hydrogen and applicable also to other gases, especially to sulphuretted hydrogen. When the stop-cock A is turned off, the acid is expelled from the flask B and driven up into the flask C. In Fig. 2 is shown the effect of metallic iron in occluding hydrogen gas. Fig. 3 shows a nice experiment based on the diffusion of the light gas, which is made to close a circuit and ring an electric bell.**

HYDROGEN was one of the earliest gases recognized by man. It was known as early as the time of Paracelsus (1493-1515), but Cavendish was the first one to isolate it, in 1776, by the action of a metal upon an acid. Joseph Priestley called it "inflammable air" (1783), and Lavoisier, a French scientist, gave it the name of hydrogen (1783).

Free hydrogen occurs in large quantities in the atmosphere of the sun, stars and nebulae, as shown by the spectroscope. Very little free hydrogen is found in the atmosphere and earth. It has been estimated that the atmosphere contains only .005 per cent. by volume. Small quantities are emitted by active volcanoes. Minute quantities are found in oil wells and the salt deposits at Stassfurt, Germany. Hydrogen compounds are very plentiful in nature in the form of hydrocarbons and other organic compounds.

Hydrogen can be easily prepared by the action of an active metal upon cold water. Such metals like sodium, potassium and calcium will decompose the water into hydrogen and the hydroxide of the metal.

$$2Na + 2H_2 = 2NaOH + H_2$$

Some heavy metals like iron will decompose steam, liberating hydrogen and forming the oxide of the metal.

$$3Fe + 4H_2O = Fe_3O_4 + 4H_2$$

The simplest way to prepare the gas is to add dilute hydrochloric or sulphuric acid to a metal like zinc, or some other metal, except gold, silver, mercury, copper and some others. The metal will displace the hydrogen and, in each case, form a salt of the metal. Set up the generator as indicated in Fig. 1. Let flask (C) have two outlets, a safety tube (D) and an outlet into the flask (B). (A) is a stop-cock regulating the gas flow from the generator. Put some zinc in the flask (B) and some dilute hydrochloric or sulphuric acid (1-5) in the flask (C). When the stop-cock is opened, the acid will flow from (C) to (B) and begin to generate the gas. Close the stop-cock (A) and the acid will be forced back into (B).

Hydrogen is slightly soluble in water. Nineteen volumes are soluble in 1,000 volumes of water at 15 degrees C. It liquefies at —234 degrees C. (—389 degrees F.) and, when it is allowed to evaporate, it will freeze into a colorless solid. Many metals and a few non-metals readily absorb it. This property is called occlusion. Palladium will absorb 900 times its volume under proper conditions. Other metals and charcoal absorb it as follows:

| | | | |
|---|---|---|---|
| Platinum | 49 | Aluminum | 2.7 |
| Iron | 19 | Lead | .15 |
| Gold | 46 | Charcoal | 2 |
| Nickel | 17 | | |

This property can be very readily demonstrated by filling a hydrometer jar with hydrogen. Invert the jar over a beaker of mercury and place a piece of iron in the jar. It will float upon the mercury. Since iron absorbs 19 times its own volume of the gas, the mercury will soon begin to rise inside the tube. (See Fig. 2.)

Gases readily diffuse through porous membranes, such as animal membranes, unglazed porcelain, etc. The speed of this diffusion is dependent upon the densities of the various gases. According to Graham's law, the relative speed at which two gases diffuse through a porous membrane varies inversely as the square root of their densities. Since hydrogen has a lower density than any of the other common gases, it diffuses more readily than the others. Set up the apparatus as indicated in Fig. 3. Put some sodium hydroxide solution in the flask (A) and color it with a few drops of phenolphthalein solution. (B) is an unglazed porcelain cup, corked, and holding the glass tube (G). Connect the dry cell and the electric bell as indicated. Fill the bell jar with hydrogen and hold it over the porous cup. Since the hydrogen has a much lower density than the air inside the cup, it diffuses into the cup much more rapidly than the air inside diffuses outward. This creates a pressure inside of the cup, which is transmitted to the surface of the liquid in the flask (A). The sodium hydroxide is forced up through the tube (D) and a circuit is formed, ringing the electric bell (E). When the bell jar is removed, the inward and the outward diffusion is the same, and the liquid in (D) returns to (A), and the circuit is broken.

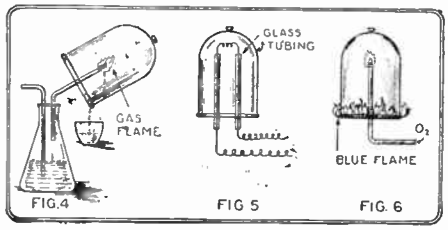



**Fig. 4 shows the formation of water when hydrogen is burned. In Fig. 5 a platinum wire is heated to redness by an electric current and a bell jar full of hydrogen is placed over it. It will cool the hot wire. In Fig. 6 is shown a flame of oxygen burning in a bell jar of hydrogen, while the hydrogen burns around the mouth of the bell jar.**

Hydrogen has a very strong affinity for oxygen. It burns readily in air or oxygen, producing water. Pass some of the gas through a drying tube containing calcium chloride to remove all of the moisture. Light the gas and you will notice that it burns with a pale blue flame. Collect the product of this combustion on a cool bell jar. It is water.

$$2H_2 + O_2 = 2H_2O$$

Hydrogen absorbs heat readily. This property can readily be demonstrated by the apparatus shown in Fig. 5. It consists of a fine platinum wire soldered in two pieces of glass tubing, the terminals are connected to an electric battery. The exposed parts of the wire will soon be heated to redness. This is due to the resistance offered to the passage of the current. If a bell jar is filled with hydrogen gas and held over the hot wire, the redness will soon disappear. This proves that hydrogen is a good conductor of heat.

Hydrogen gas is non-explosive and non-inflammable when pure. It, however, gives an explosive mixture when it is mixed with air or oxygen, and it burns in air with a blue flame. If a bell jar is filled with pure hydrogen and is lit and some oxygen is passed into the bell jar through a tube, it will ignite. The hydrogen will burn with a beautiful blue flame around the edge of the jar, forming water. The oxygen from the jet will burn in the atmosphere of hydrogen, and the hydrogen at the mouth of the jar will burn in air.

When pure, dry hydrogen is passed over a hot oxide of a metal, it will readily combine with the oxygen of the oxide and form water and leave the pure metal. Place a small copper crucible upon a tripod and heat it with a Bunsen flame. It will soon lose its bright copper-red color and become coated with a thin film of black copper oxide. If a funnel is connected with a hydrogen generator and dry hydrogen is passed over the hot crucible, the original color will soon reappear. This is due to the fact that the hydrogen reduces the copper oxide to metallic copper.

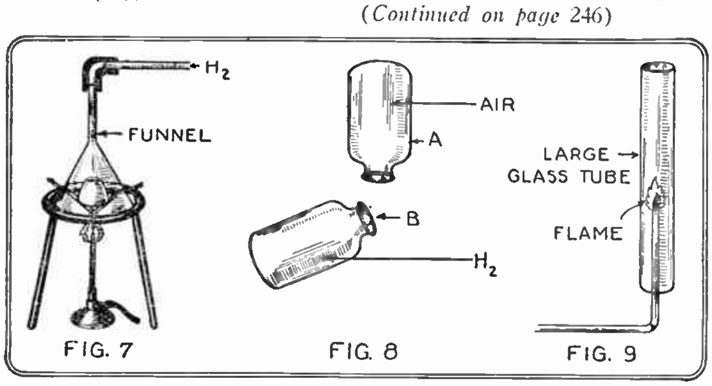
$$CuO + H_2 = Cu + H_2O$$

Hydrogen is 1/14.14 times the Sp. Gr. of air, therefore it will readily displace air from a vessel by pouring the gas upward into a bottle filled with air, as shown in Fig. 8. Jar (A) is filled with air and jar (B) with hydrogen. When the necks of the two bottles are brought together, as in the illustration, the hydrogen, on account of its low density, will displace the air from bottle (B). If a lighted taper is inserted into each of the bottles, a slight explosion will occur in bottle (A), and nothing will happen in the other. This lightness gives it a great lifting power and, for this reason, it is used in balloons and dirigibles.

A very interesting, but peculiar, phenomenon of hydrogen is the singing flame (Fig. 9). Dry hydrogen gas from a generator is lit and a large glass tube is placed over the flame. A singing noise is produced by the

*(Continued on page 246)*

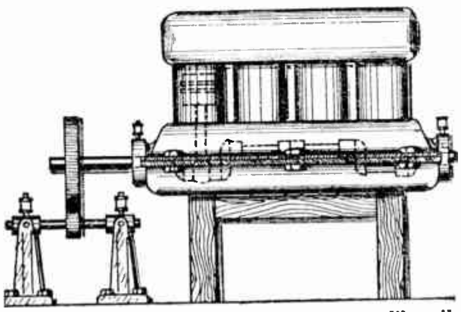
**Hydrogen is passed down through the funnel, reduces a deposit of copper oxide which has been formed upon the crucible. Fig. 8 shows how to hold two bottles for pouring hydrogen up into a bottle of air, and Fig. 9 shows the arrangement for producing the singing flame; if properly conducted a small flame will produce an almost intolerable noise.**



# Experiments With Various Catalysts

By EARLE R. CALEY, B. Sc.

A CATALYST, in chemistry, is usually defined as a substance which greatly changes the speed with which a chemical reaction takes place, and yet does not appear to be itself involved in the reaction. These substances, by their very presence, seem to retard or accelerate



**A catalyst in a chemical reaction acts like oil in a machine. Just as oil makes a machine run smoother and faster and yet does not change, so does a catalyst make a chemical reaction go smoother and faster and yet comes out from the reaction unchanged chemically.**

chemical reactions in a marked degree. The large and constantly growing importance of these substances in the field of industrial chemistry make them interesting objects of study at the present time. The following simple experiments serve to show the various kinds of these substances and their use in reactions.

### Experiment I

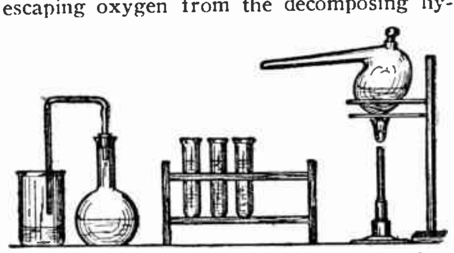
It has long been a known fact in chemistry that finely-divided platinum, sometimes called platinum black, has the power to cause the union of combustible gases with oxygen. This catalytic action of platinum may be shown in the following manner. A very small amount of platinum black is first to be prepared. This is done by soaking a piece of fibrous asbestos in a 5% solution of chlorplatinic acid and then strongly igniting it for a half-hour in a Bunsen burner flame. By this means a quantity of finely-divided platinum is deposited upon the fibre. When this prepared fibre is introduced into a mixture of hydrogen and oxygen gases prepared by the electrolysis of water (10 c.c. of gas is sufficient) the gases combine.

### Experiment II

Alcohol when dropped upon some of this prepared platinum black is oxidized and the odor of the oxidation product, acetic acid, becomes perceptible. Oftentimes the rise of temperature due to this reaction causes the alcohol to inflame.

### Experiment III

The unstable compound hydrogen dioxide, which breaks down slowly under ordinary conditions, is rapidly decomposed by various catalysts sometimes with almost explosive violence. To show this about 10 c.c. of 30% hydrogen peroxide is placed in a test tube and a pinch of bone black added. A violent evolution of gas occurs due to the escaping oxygen from the decomposing hydrogen peroxide. The bone black may be filtered off apparently unaltered. Finely divided manganese dioxide and platinum black also cause the decomposition of the hydrogen peroxide catalytically.



**Chemical apparatus which is used to show catalytic action.**

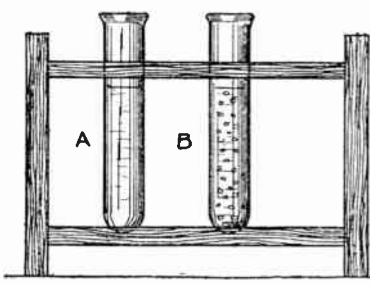
### Experiment IV

Another type of catalysis is caused by the action of a voltaic couple. When a few grams of C.P. (chemically pure) metallic zinc are placed in a test tube and about 10 c.c. of dilute sulfuric acid are added there occurs only a slight reaction. If now, however, a drop of 10% copper sulfate solution be added to the mixture a vigorous evolution of hydrogen gas occurs.

A similar action is made use of in preparing the reagent stannous chloride for use in laboratories. When pure tin is placed in a solution of hydrochloric acid in order to make stannous chloride the action is very slow. In order to increase the speed of the action a piece of platinum is frequently added. This serves as the catalyst and makes the reaction proceed much faster. These last two experiments fall under the head of electrolysis.

### Experiment V

A type of catalytic reaction frequently employed in organic syntheses is known as Friedel and Craft's reaction. This depends upon the catalytic action of anhydrous aluminum chloride. When 5 c.c. of benzene $(C_68_6)$ are placed in a test tube and a few drops of chloroform are added no action is evident. But as soon as a slight quantity of perfectly anhydrous aluminum chloride is added a vigorous reaction results and dense white fumes are evolved. The mixture in the test tube turns a dark brown color and the product of the reaction is known as triphenglmethane. The success of this experiments depends upon the employment of perfectly dry aluminum chloride. This should be freshly prepared for the purpose or taken from a freshly opened container.




**Ordinary hydrogen peroxide decomposes very slowly into water and oxygen when left to itself (A), but if a slight trace of maganese dioxide or platinum black is added to it (B), a violent decomposition takes place, yet the catalyst added may be recovered unchanged.**

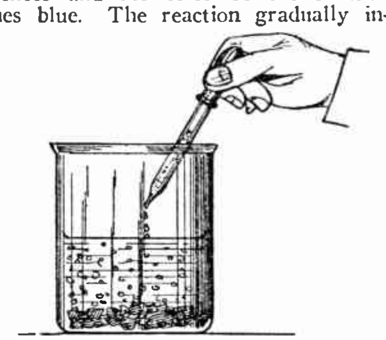
### Experiment VI

Starch and similar polysacharoses are changed by hydrolysis (action of water) to simple sugars, usually glucose. When the starch is simply boiled with water the reaction is quite slow. When, however, a slight amount of an acid or an alkali is added to such a mixture the reaction speeds up and the glucose is readily produced. This may be shown by the following simple experiment.

Two beakers are provided. In each place about 2 grams of starch. To one of them add 50 c.c. of distilled water; to the other add 50 c.c. of a 3% sulfuric acid solution. They are both boiled about half a minute. After cooling and neutralizing the acid solution with 10% sodium hydroxide solution, they are both tested with Fehling's solution for glucose. The one that has been treated with the acid will give the characteristic red precipitate of cuprous oxide while the other will fail to respond.

### Experiment VII

An example of a catalytic reaction in which the velocity of the reaction slowly rises to a maximum and then dies down to zero again is afforded by the following experiment due to Spitalsky. 20 c.c. of a 20% solution of hydrogen peroxide to which has been added 5 c.c. of a chromic acid solution (prepared by dissolving .33 grains in 1000 c.c. of water) are carefully heated in a test tube to 50° C. The reaction slowly commences and the color of the solution becomes blue. The reaction gradually increases in velocity until at the end of 10 minutes a violent action takes place and the color of the solution becomes violet. Then the reaction becomes less and less violent until it ceases altogether and the solution again presents its original appearance.

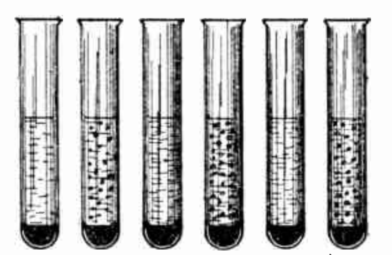


**Pure zinc placed in dilute sulphuric acid decomposes the acid slowly with evolution of hydrogen, but if a few drops of copper sulphate solution are added, the action becomes quite rapid.**

### Experiment VIII

This experiment illustrates one of the most interesting types of a chemical reaction, the so-called periodic reaction. This is a peculiar kind of a catalytic reaction in which the reacting substances are present together in the same vessel and yet react only at certain intervals. To show this a mixture of 3.3 c.c. of 30% hydrogen peroxide, 6.7 c.c. of distilled water and 33 c.c. of a 20 % sodium acetate solution is placed in a large test tube.

A small drop of clean and pure mercury is now added. After a few minutes a brown coating of oxide is formed upon the mercury surface which then disappears suddenly, accompanied by the sudden evolution of oxygen gas. The coating of brown oxide reforms and the process is repeated. By varying the proportions of the reagents used the time interval or beat of the reaction can be varied.




**The action of mercury on fairly concentrated hydrogen peroxide is a very interesting example of catalysis. The mercury periodically causes gas evolution from the hydrogen peroxide, which ceases and is resumed with a degree of regularity.**


# The Cathode Ray Oscillograph

By Dr. Bacher

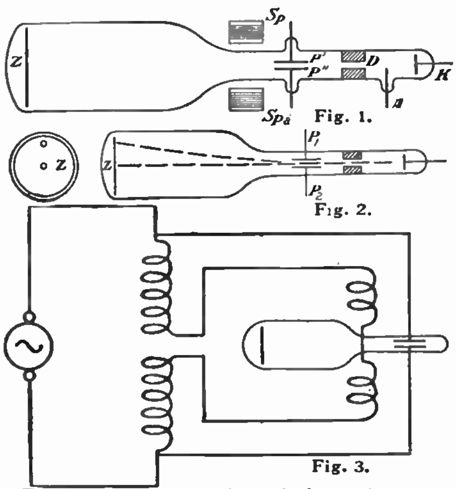


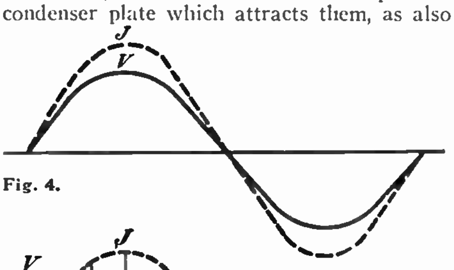

**Fig. 1, the construction of the cathode ray oscillograph tube. Fig. 2, the deflection of the cathode ray under the influence of the electrostatic field between $P_1$ and $P_2$. Fig. 3, the electrical circuit of the oscillograph.**

EVERYTHING oscillates nowadays, sound, heat, light, electric waves are commonplaces, but who has ever seen the waves? Can it be proved that the distant concert reaches our ear carried through space by electric oscillations, and can these waves be rendered visible? They can indeed; as far back as 1897 Professor Ferdinand Braun succeeded in demonstrating the nature of cathode rays with his oscillograph, shown in Fig. 1. It is a vacuum tube with narrow neck, (A) and (K) are anode and cathode respectively, (D) diaphragm, (P-P) condenser plates and (Z) a mica screen coated with sulphide of zinc to make it radio-active.

With a negative continuous potential at (K) the electrons pass through the diaphragm and its fine opening is represented on the screen by a luminous point. So long as the condenser remains neutral, the electrons follow a straight course; the moment, however, the condenser is made active they are deviated and from the shape of their path reflected on the screen, we observe that it is the positive condenser plate which attracts them, as also that deflection is in proportion to the tension at the condenser. (Fig. 2). A magnetic field has the same effect and to demonstrate this, coils (Sp) and (Sp-a) (Fig. 1) when shunted in series will deviate the ray at right angles to their magnetic lines of force.

For alternating current the relative position of condenser plates and coils has been so chosen, that their respective deviations are at right angles to one another and both will show to the eye luminous lines in consequence of the rapid change of polarity, the two lines forming a cross on the screen. Connecting condenser and coils to the same circuit (wiring diagram, Fig. 3) one would think that they would compensate under 45 degrees; this however, is not the case, as intensity and tension do not rise and drop simultaneously, as per Fig. 4; their phases are stepped or lag according to Fig. 5 which shows a perfect alternating current with phases at 90 degrees to each other.

On comparing Figs. 5 and 6 we find the following: The circumference of Fig. 6 represents the phosphorescent screen, (O) its center is at the same time the luminous point caused by the electrons when condenser and coils are inactive, (A) is the horizontal deviation, caused by the condenser, (B) is the vertical deviation of the coils. After closing the circuit we begin our observation at point (a) (Fig. 5), intensity I = O, tension V = (Va). The projection of the two points coinciding on the horizontal axis, we may assume the point (Pa) of Fig. 6 to indicate their position with (O-Pa) equal to (Va) on Fig. 5 as the maximum deviation caused by condenser.



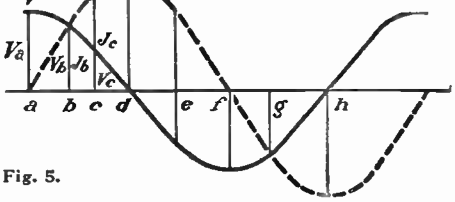




**Fig. 4 shows two sinusodial waves in phase. Fig. 5 shows the effects on the cathode ray of the electrostatic field (V) and of the magnetic field (J).**

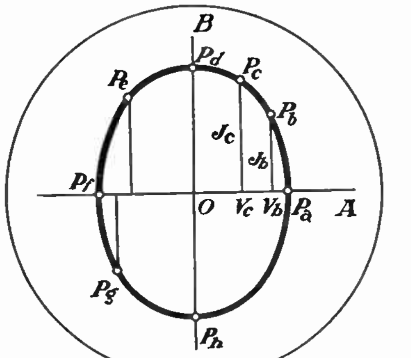



**Fig. 6. The line traced by the cathode ray on the fluorescent screen when the oscillograph is excited by a sinusodial alternating current.**

Advancing we find (Pb), (Pc), until (Pd) is reached, when (O-Pd) equals (d-I) of Fig. 5, representing the maximum intensity with (V)=O, both points coinciding on the vertical axis. (Pe), (Pf), (Pg), (Ph) back to (Pa) is the path of the ray of electrons representing one complete wave and Fig. 7 is the impression it leaves on a photographic plate. This so-called "Lissajou figure" has the shape of an ellipse with its centers on the deviation axis when dealing with alternating current of phases at exactly 90 degrees. To ascertain the nature of such a current it is only necessary, after the photograph has been taken to separate the deviations by switching off in turn condenser and coils. Leaving the plate in its original position, and allowing sufficient time for exposure a picture like a figure 8 will be obtained. The extreme possibility is that with phases at 45 degrees apart, when a straight line appears in place of the ellipse, the line being inclined at 45 degrees.

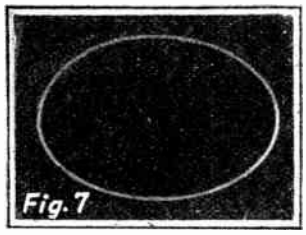



**Fig. 7. A photograph corresponding to Fig. 6.**

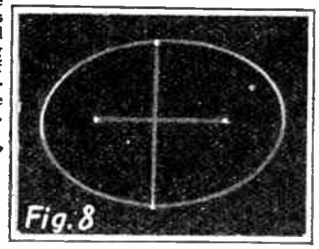



**Fig. 8. The crossed lines are produced by alternating the action of the electrostatic field and the magnetic field.**

Perfect alternating currents are hardly ever produced by dynamos and the oscillograph is an excellent means to analyze the output. Fig. 9 shows a performance with superposed strong oscillations of the third harmonic coupled to the fundamental oscillation, whilst the egg-shape in Fig. 10 is caused by a harmonic oscillation of double frequency.

It is abvious that with undamped oscillations we are independent of the number of frequencies, no matter how high they may be. The print on the plate will always be a closed curve correctly representing the relation between tension and amplitude, as the cathode rays are practically devoid of inertia. For experiments with damped oscillations, however, an auxiliary device is required.

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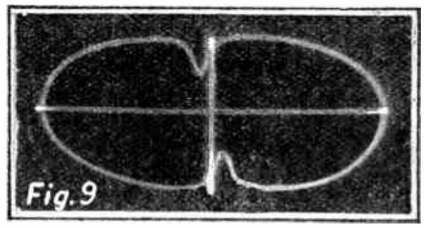


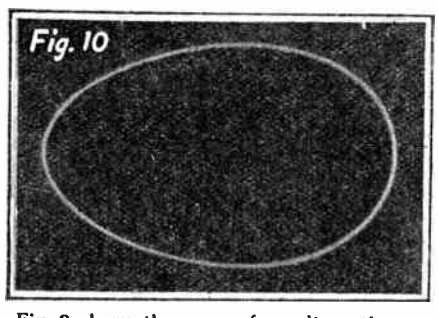
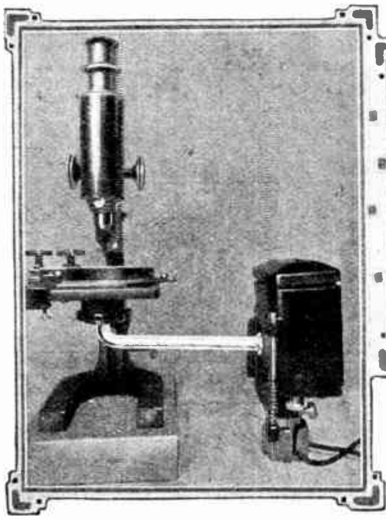
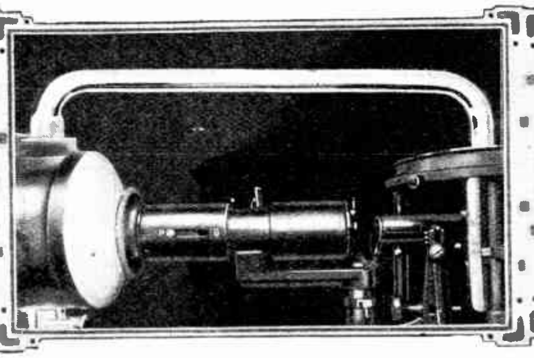



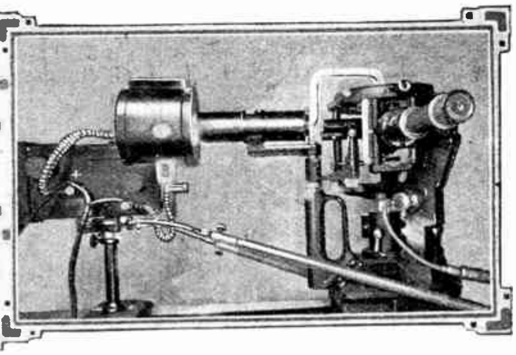

**Fig. 9 shows the curve of an alternating current with a strong third harmonic. Fig. 10, the egg-shaped curve results from a second harmonic in an alternating current.**

# Microscope Illumination by Means of Quartz Rod

By S. B. Leiter







**On the left is shown a vertical microscope with a sub-stage illumination carried to it through a one-half inch quartz rod. In the center the light from an arc lamp is carried to the stage of an inverted type microscope. Here the light has to go around two corners. On the right is shown another arrangement which is highly efficient, but there is a tendency to have ash collect upon the end of the rod and interfere with its action. This arrangement can be used for micro-photography. The quartz rod operates by internal reflection. This phenomenon is applicable to glass and is used in the Fresnel lens in lighthouses.**

THERE has been considerable discussion of late in regard to the light carrying properties of quartz. Much stress has been laid on the ability of the quartz rod to bend light rays around corners. This in itself would not necessarily set quartz apart as peculiar. Light passing through any transparent rod or tube with reflecting walls will "bend" around a corner, but the absorbing power of quartz is low, the melting point high. These latter characteristics make it a very convenient substance to use for microscopic illumination as will be shown by the following photographs, especially in the case of the inverted type of microscope where illuminating a transparent specimen has presented some difficulties.

Fig. 1 shows the arrangement for substage illumination for work with an ordinary small microscope. The lamp at the right is a small moving picture outfit lamp from which the lens has been removed. By means of a half inch quartz rod the light is directed to the stage of the microscope, is always where it is wanted, and there is less loss of intensity than when the light is reflected from a substage mirror.

Figs. 2 and 3 illustrate two methods of carrying the light from an arc to the stage of the inverted type of large microscope. Slightly greater intensity is obtained with arrangement shown in Fig. 3 and in this case the quartz rod can be supported so that with a very slight adjustment it can be brought into use at any time. On the other hand, it has the disadvantage of making necessary some device for preventing the covering over of the end of the rod by the little white ash from the burning of the carbon. However, a small current of air through the top of the casing above the arc should keep the rod clean. The end of the rod toward the microscope should be ground uniformly. but not polished. Although diffused light is thus obtained, it is sufficiently intense for photographic purposes and gives better detail than ordinary methods of illumination.

In this connection I might mention another use for the quartz rod. In any case where the source of light is an incandescent lamp, if the light is allowed to pass through a short length of quartz rod with ground end, all trouble from images of the filament is obviated without loss of light. It is possible to work farther from the source of light to avoid heating of specimen.

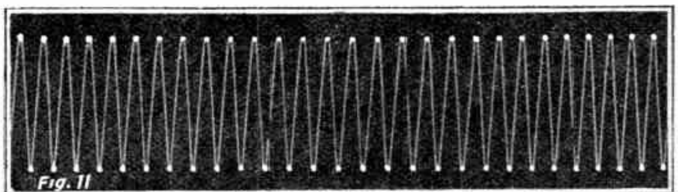
## Cathode Ray Oscillograph

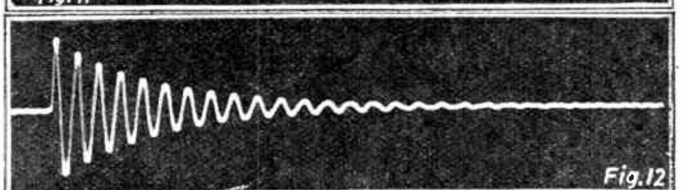
(*Continued from preceding page*)

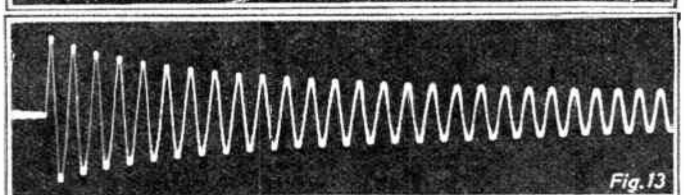
We are indebted to the German physicist Kurt Krueger for the description of some experiments with the oscillograph in the analysis of radio oscillations. To understand them let us consider oscillations of constant amplitude in their effect upon the coils alone. On the screen they will produce a straight luminous line showing the maximum deviation and they will therefore be of little use unless we find some means to introduce the factor of time. This can be achieved by the introduction of a rotating reflector, better and more simply, yet by means of a sliding chassis instead of a fixed plate. Fig. 2 is a photograph of such an undamped oscillation obtained by a specially constructed camera, whilst Figs. 12 to 14 show the result of other undamped oscillations. In the case of Fig. 12, a circuit with capacity and self-induction was discharged through the coils, and Fig. 13 has been obtained with the same circuit, but damping was reduced purposely by means of a vacuum tube shunted in reaction. Fig. 14 finally is the outcome of another circuit close-coupled to the former.

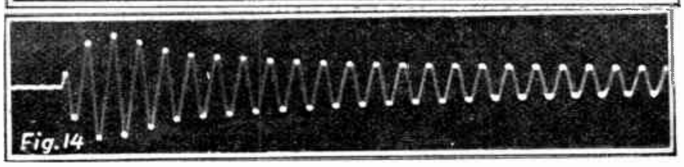
An inconvenience is the limited sensitiveness of photographic plates and it has not as yet been possible to register oscillations exceeding 2000 per second, owing to the excessive speed required for the movement of the chassis. Photos Nos. 12 to 14 have been ob-

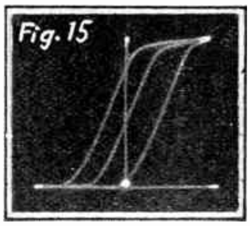
(*Continued on page 247*)



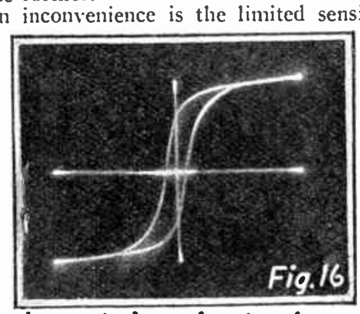



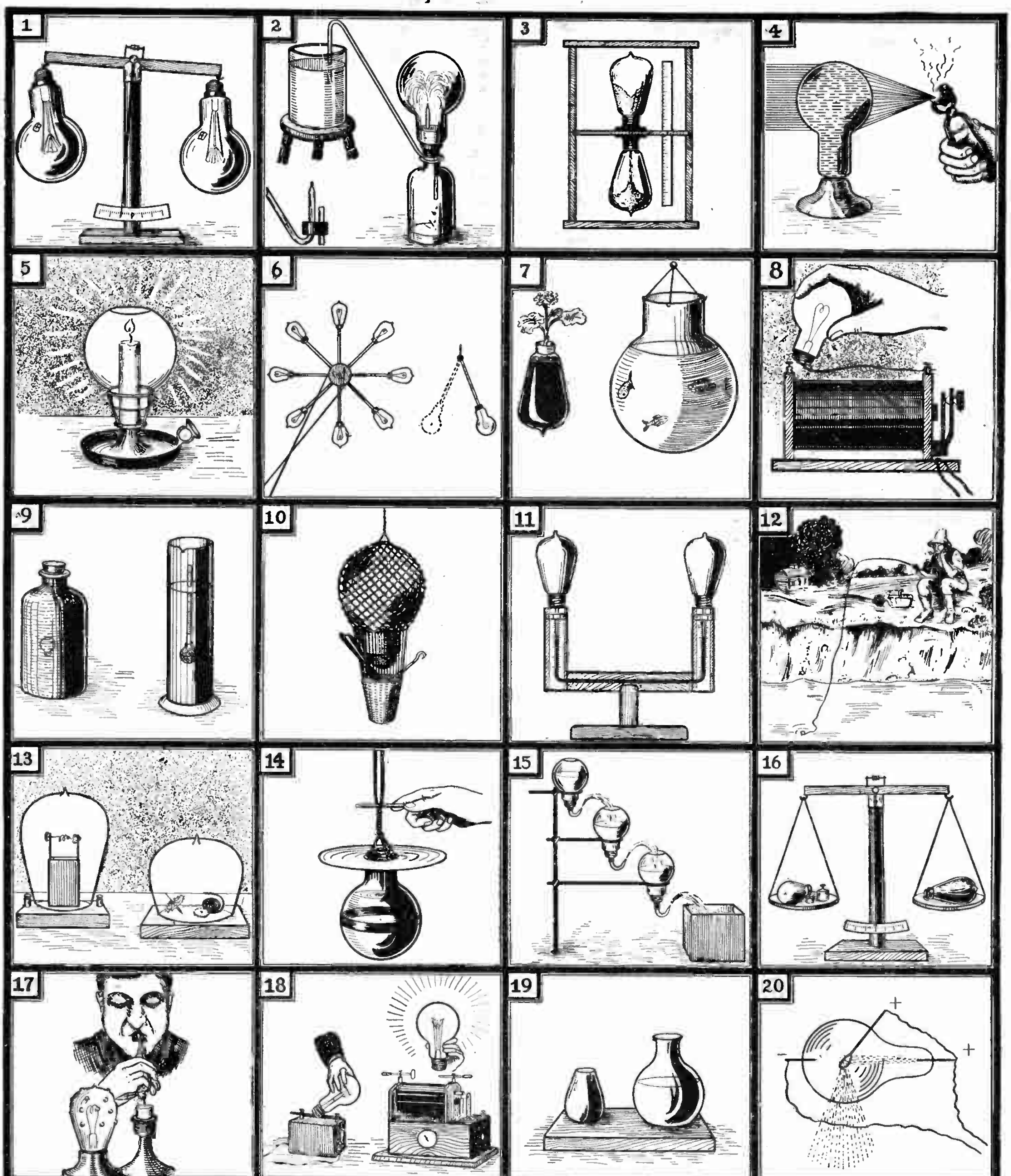

**Some examples of the records produced by cathode ray oscillograph. Fig. 11 is a continuous oscillation. Figs. 12, 13 and 14 show the decay of current in an inductive circuit. Fig. 12 shows a highly damped oscillatory current. Fig. 15 shows the characteristic curve of a vacuum tube for various plate voltages recorded by the cathode ray oscillograph.**



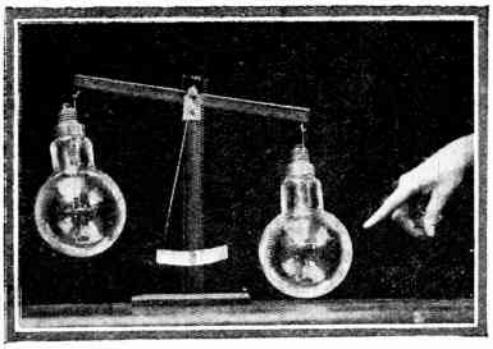

**The hysteresis loop of a transformer core ordinarily obtained by a tedious plotting method is rapidly recorded by the cathode ray oscillograph.**

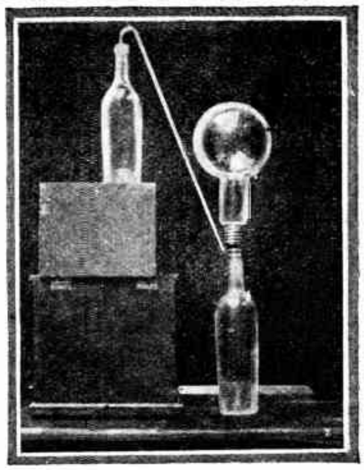
# Experiments With Old Lamp Bulbs

By Ricardo Ludeke




1. Poising two bulbs on a balance; when air is admitted to one it descends because the admission of air disturbs the equilibrium. 2. A fountain siphon; quite a pretty experiment, sometimes called Hero's fountain. 3. A sand glass. Be sure your sand is of fine grain and even sized granules. Pass it through two sieves of different mesh, and take the intermediate size of sand. 4. A bulb filled with water lights a bit of cotton or a match, when used as a burning glass. 5. A neat shade for a bedroom candlestick. 6. Moving targets to try your ability with a rifle or pistol. 7. Vegetable and animated nature accommodated in two bulbs. The fish must be very small or the bulb very big. 8. A bulb used as a Geissler tube. 9. Hydrostatics; on the left the Cartesian diver; on the right a hydrometer. 10. This time we come to ornament. A balloon is supposed to be represented by a bulb and in the car or basket odds and ends may be placed. 11. An air thermometer; its sensitiveness would depend upon the calibre of the bulbs in relation to the calibre of the tube. 12. A fisherman uses a bulb for his float. 13. Bulbs cut off and with the edges ground are used as bell jars. 14. A nice experiment in centrifugal force, capable of all sorts of variations. 15. Water going downstairs step by step, in other words, from bulb to bulb. 16. Testing the specific gravity of a fluid by filling a bulb which has been weighed when empty, first with water and then with the fluid each time it is weighed, and a simple calculation gives the result. 17. Using a blow-pipe on a bulb in order to produce depressions on its surface. It may be punctured in this manner if desired. 18. The Tesla experiment, using two induction coils and two bulbs. A small coil gives the high frequency make-and-break effect. 19. Vases made out of bulbs; very careful heating before the bulb is punctured will flatten the base. 20. An attempt to use the bulb as an X-ray tube. Success will be far from certain.





**Two bulbs are poised on a balance. By admitting air to one of them it will be found to weigh the heavier.**
**On the right is shown the set-up for Hero's fountain, which is a sort of siphon.**

**An air thermometer is shown above. The heat of the hand is quite sufficient to move the column of liquid.**

**This is the most daring of the attempts, with the exception, perhaps, of the X-ray tube. This connection is used to give high frequency Tesla discharges.**

TWO bulbs of the same size are balanced accurately on a common balance. Then one of the lamps is filled with air by filing the point of the bulb until a minute hole is formed. The end of the balance on which this bulb is replaced descends, proving that the air has weight.

A fountain like Hero's can be made with a 100-watt lamp. Carefully withdraw the filament and the socket and fix two glass tubes, as shown, with sealing wax on the base of the bulb and connect to a bottle using a perforated cork and glass tubes as shown.

As shown a sand glass can be made from two lamp bulbs, opened at the bases and connected by a glass tube closed a little at the center to form a stricture. Sand perfectly dry is used in quantity to give a difinite time of flow.

A 200-watt lamp filled with clear water is an excellent magnifying glass.

Shows a light protector.

Shows two systems of moving targets to test the ability of a marksman with rifle or pistol. One is swung pendulum fashion, the other is revolved at any desired speed, and shots are taken as the bulbs are in motion.

Bulbs may be used as gold fish globes or as plant or flower pots, if the fish are small. The next experiment is highly interesting. A simple Ford coil and 100-watt bulb with broken filaments will give excellent results. Connecting both lamp terminals to the secondary terminals of the coil, a strong violet spark is obtained between the broken filament terminals. (Geissler experiments.)

Holding the bulb in one hand and connecting it directly to one terminal of the coil, strong induced low frequency sparks flow from the filament to the glass bulb and to the hand. You will feel a slight tickling on the fingers.

Holding the lamp at a little distance from the terminal so that a spark will spring from the coil to the bulb terminal, high frequency currents are obtained in the interior of the lamp and strong violet light will be produced. (Crooks' experiment. Cathodic rays.) This last experiment is very beautiful and interesting.

After all these experiments you can notice a luminous greenish color in the interior of the lamps, like the color of X-ray tubes.

These experiments must be made during the night or in a dark room. Try different makes of lamps until good results are obtained.

Small auto lamps can be used as the bulbs of hydrometers and to show transmission of power through liquids.

A small bulb ballasted and open at the bottom in a bottle filled with water will rise and descend as the cork is pushed down or released; this experiment is called the Cartesian diver. Tinted or painted bulbs can be used as Christmas tree decoration.

With two empty bulbs and a curved glass tube containing colored water, an efficient differential thermometer can be constructed. The size of the bulbs if a small calibre tube connects them makes it very sensitive.

A small Everyready lamp may be used for fishing, instead of the regular cork float long used by the disciples of Isaac Walton.

Cutting the glass with a diamond, good covers for detector and little bell jars for covering small screws and the like for the watchmaker at his work are provided. Smooth off the rough edge by grinding with sand on a pane of glass. A few minutes will suffice to do this.

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The investigation of specific gravity can be made in the following manner. Three bulbs of the same weight and volume are needed. One is filled with distilled water, the other with the fluid of which we want to know the specific gravity. The empty bulb is put on one pan of the balance and on the other the water and other fluid which are weighed.

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The Tesla experiment is not new but will interest all experimenters. Different makes of lamps give different effects. It is not necessary to connect terminals; by holding the lamp between the two terminals of the secondary a clear luminous light is the effect obtained.

A good deal of ingenuity has been shown by the author in devising this series of experiments. It may be acknowledged that some of them will be rather difficult of execution, but the idea is to show the extreme possibility of the attractive looking lamp bulbs, which we so often throw away when the filament is broken. In the twenty experiments which are here shown, the possibilities are by no means exhausted, for it will often be found that other experiments with discarded lamp bulbs have been devised, and several have been shown in our columns.

Considerable knack is required in doing some of them; thus, taking No. 14, a disc of wood, or an old phonograph disc must be connected to the bulb as shown, in order to so establish the locus of the radius of gyration, so that the bulb will revolve in a practically fixed position. If all is in balance the bulb will seem motionless, although it may be whirling around at great speed.

In articles on glass-working, we have described the cutting of bottles and the smoothing of the cut edges and other details. Much that is said there will apply to the treatment of these bulbs. One point is, however, that the glass of the bulbs is very thin, and that it is fair to consider it of quite a different temper than the glass of a bottle, so that there will be a certain difference in working it.

We hope that this very interesting article will be an inspiration to some of our readers, and that they will send us some more suggestions for doing interesting things with bulbs.

# Sensitive Galvanometer

## By David Terriere

THE galvanometer herein described is of the moving coil type and is very sensitive and accurate. In the moving magnet type the size of the magnets is limited and thereby the sensitiveness of the instrument is cut down greatly. This instrument, having a moving coil, enables the constructor to use a large and very powerful electromagnet, but the coil must be small to assure sensitiveness and quick action. In order to meet these requirements a wire of extremely small gauge is required.

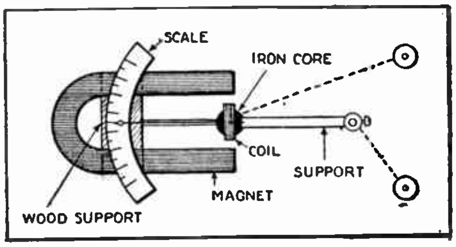



FIG. I

**Horizontal view looking downward upon the essential portions of a very sensitive galvanometer. A permanent horseshoe magnet supplies the field and a coil of No. 40 enameled wire moves the indicating needle.**

To proceed with the construction: The first necessity is a permanent magnet of the ordinary horseshoe type. This is shown in the illustration, and it should be bent on the flat instead of edgewise, as most magnets are. Such magnets are easily procurable. This magnet is mounted on a small wooden block, as shown, which block also serves as a support for the core and scale. The core is a small piece of cast iron and serves to concentrate the lines of force between the poles of the magnet. It does not move, being fixed to the base.

The core is drilled radially and the hole is tapped for an 8-32 thread. A small piece of brass rod is screwed into this hole, and the other end of the rod is fitted tightly into a hole in the wooden base block. The core should now be exactly centered between the pole pieces, as shown in the illustration. The magnet itself should be given a coat of enamel and then placed in the position shown in the drawing and clamped down with a strip of brass screwed down to the block of wood.

Now to turn to the construction of the coil. The form for this coil is made on a block of wood about 3/4 inch square. A few layers of paper are wrapped on this form, which should be slightly tapered to facilitate the removal of the coil after winding. Two strips of paper should be wound parallel towards the ends of and over this paper to form a slot 1/16 inch wide and 1/4 inch deep. Six or eight threads should be laid across this slot before winding.

The slot is wound full of No. 40 enameled wire in close, even layers over the threads, whose ends extend to right and left. Place as much wire as possible on the coil. An 8-inch length of wire should be left at both ends and the ends of the threads which were laid across the groove are to be tied to hold the winding together. The coil is removed from the form and wrapped with narrow strips of friction tape. The ends of the winding should then be brought out at opposite sides of the square coil. It should be given a couple of good coats of shellac and allowed to dry.

The support for the coil may be made by winding a No. 18 copper wire once around the coil and twisting together where one of the wires from the coil comes out. This piece of heavy wire should have one end about 2 inches long, and this is bent to the form shown. The end of the wire is sharpened to a point and rests in a small depression made in the brass arm which slides up and down the standard, and this is permanently fastened to the small copper tube, which has a set-screw to clamp it in any position. The depression in which the copper wire rests has a small drop of mercury placed therein to assure a good electrical connection. The pointer is placed in position by running it underneath this wire, where it is fastened to the coil proper. The pointer can be made of a piece of brass wire flattened on one end and touched up with a little black enamel.

On the opposite end of the pointer is mounted a counterpoise weight. This can be made easily by winding the wire in a close spiral, and, after the instrument is assembled, clipping off a short length at a time until the armature balances centrally on its pivot. The needle can be fastened by means of fine silk thread and shellacked to hold it stiffly in place. The next consideration is the scale, which is mounted on the magnet. It consists of a piece of zinc cut to the shape shown. A scale made of smooth white paper is center. Divisions on the scale may be made calibrated in degrees with the zero at the to suit the fancy of the constructor, but ten to the inch is usually sufficient.

The bottom lead wire from the coil is twisted into a spiral and soldered to a copper washer. A bolt is put through the center of the washer into the base and one connection is made to the screw. In adjusting the instrument, if the pointer does not rest on zero, it is merely necessary to turn this washer a few fractions of an inch in the proper direction until the pointer reaches the zero mark, and clamp it there by means of the nut. It would be advisable to make the baseboard large enough so that a glass bell jar can be placed over the galvanometer to protect it from dust and moisture.

Very few measurements have been given, as a great deal depends upon the size of the magnet available and upon what odd pieces of scrap are at the constructor's disposal. The details can be varied greatly if reasonable care is exercised to get the parts in the proper proportion.

The instrument is now complete and may be tested. It is well to remember that this galvanometer operates on very small currents, and powerful currents should not be used or the instrument will be burned out.

When powerful currents are to be measured, adequate resistance wire should be placed in series. A good method of testing the sensitiveness of this galvanometer is to take an ordinary half-dollar, connect one wire

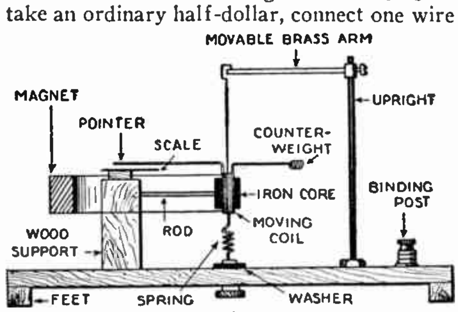


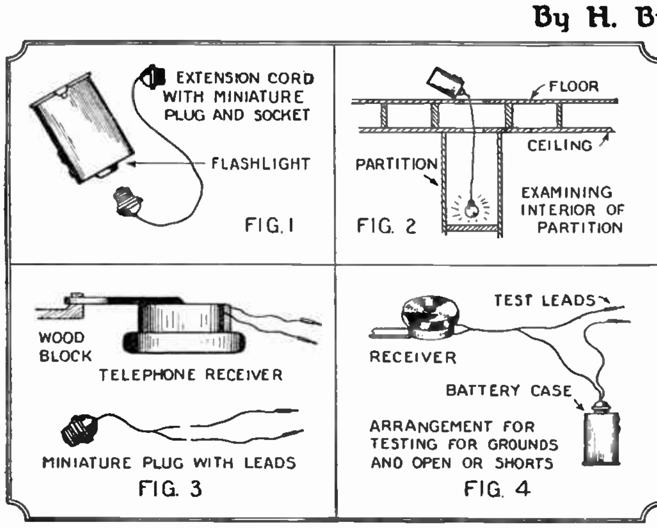

FIG. 2

**A side view in elevation and in section of the sensitive galvanometer. Here the counterweight is shown which keeps the pointer horizontal.**

to it and lay a piece of flannel soaked in salt water on top of the coin. Now touch this flannel with a copper wire connected to the other terminal of the galvanometer. A deflection of at least half an inch should be obtained, which would indicate that the instrument is in excellent working condition.

# Some Testing Tips

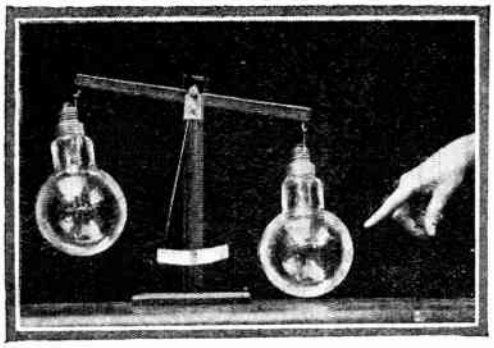
## By H. Bushlowitz, E. E.

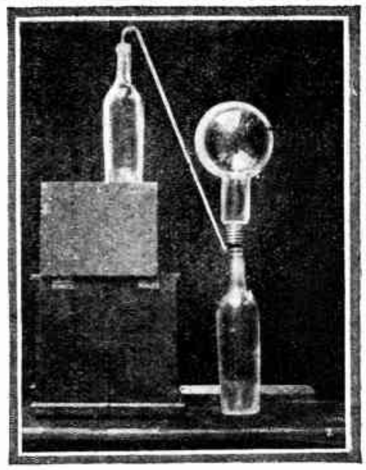



**Simple suggestions for the house-wiring electrician. A flashlight battery supplies a lamp through a long, flexible cord which can be dropped down into small places for examination, as shown in Figs. 1 and 2. In Figs. 3 and 4 is shown the use of a telephone receiver for finding grounds, open circuits and short-circuits. The telephone is attached to a block of wood to be held by the teeth.**

FROM time to time all kinds of electrical apparatus should be tested for trouble, phase outleads, etc., or to overcome difficulties in wiring. It is often possible to get along without special apparatus if a little ingenuity is employed, but it means a lot of lost time. It is entirely possible to test out circuits by connecting to the water and gas mains for juice, and use the receiver off a telephone for an indicator when nothing else is at hand; or standing on a dry board to find a blown fuse with the fingers. But why bother, when a few pieces of apparatus taking no more room than a small camera will save minutes and often hours on the job? Few electricians will have use for all the instruments, but they are handy for the man who has to drop his tools, roll up his sleeves and tackle anything from repairing a doorbell to wiring an apartment house.

The first requisite is a pocket flashlight. The small, flat, nickel-plated lamps are rea-





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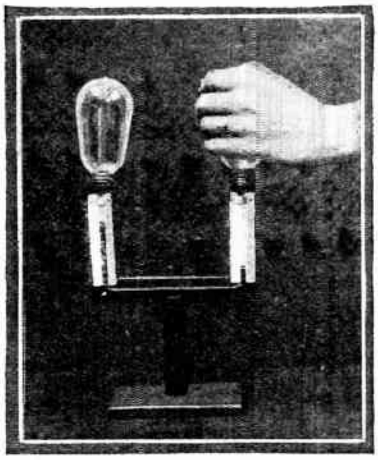

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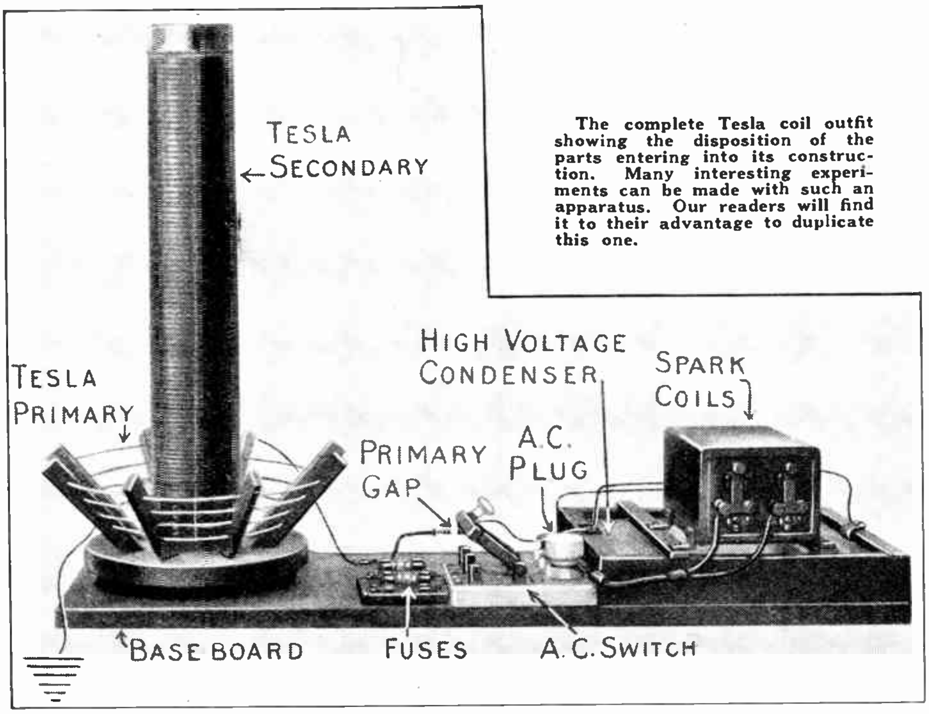
# A Practical Tesla Coil

By Willis L. Nye




The complete Tesla coil outfit showing the disposition of the parts entering into its construction. Many interesting experiments can be made with such an apparatus. Our readers will find it to their advantage to duplicate this one.

THE applications of a Tesla transformer for an experimenter who is interested in high frequency electrical phenomena are numerous and a few hints as to the construction of a coil of moderate cost will be a help to many interested in this subject.

The wonderful effects of the electrical discharges from the coil, together with its practical usefulness in testing the quality of insulators and antennas, besides furnishing an endless store of entertainment for the uninitiated who have not dabbled with any high frequency currents, make it a piece of apparatus of much importance to many of us. The coil to be described here can be very quickly assembled and its moderate cost is not excessive providing the materials specified are used in its assembly.

The power transformer is the most necessary item of the group of parts comprising the equipment and the best material should be used in its manufacture, because here lies the principal source of energy. The output of the transformer should be not less than ¼ K.W. of power and preferably more if a higher efficiency is to be obtained. Any transformer capable of delivering the necessary voltage may be used although the type described will function much better. At any rate use the best transformer possible.

The first integral part of the power transformer is the core. It is composed of No. 20 or No. 22 iron bundle wire which should be tied together after the individual wires are cut to the proper length and the ends ground smooth so as to present a neat job and better electrical efficiency. A pound and a quarter of No. 16 D.C.C. copper wire is about all that will be required for winding of the primary. The iron core wire after it is finished on its ends with grinding and with emerycloth is untied and next is softened by heating to redness, in a charcoal fire and gradually cooling until the fire is burnt out. Keep it well buried in the ashes until cold. The individual wires should then each be emoried clean and then given several coats of shellac. The heating process is to help make the core of very permeable nature and low hysteresis in respect to the electromagnetic lines of force. The core wires are made up first in a little central bundle and gradually laid together. Wrap oily paper in between each layer as you progress so that each layer is separated by the oily paper. Proper and firm building of the coil is a necessity.

After the core is finally assembled the whole is wrapped in cambric and given several coats of shellac. Wind enough cambric on the core so as to take up excess play between it and the bakelite tubing which the core is to fit into. On this tubing with the core inside the bobbins will be slipped and fastened. The tubing will be about 2¼" outside diameter. Firmness in this respect is necessary.

The bakelite tubing holds the bobbins; its side should not be less than ⅛th inch in thickness. The bobbins on the core after they have been properly wound and properly fastened, are shellacked. The bobbins had better be wound with a revolution counter on the winding apparatus so that proper count of the turns is known at all times.

In winding both the primary and the secondary note the direction in which the turns are wound so that proper direction of the lines of force will be established or else your transformer will be worthless. Wind every bobbin with a firm, stiff winding and keep all the wires taut and after completing the winding give a coat of collodion to the windings so they will remain always as wound.

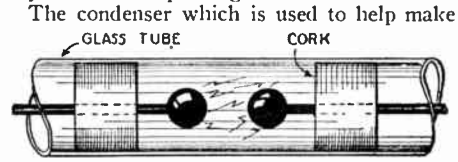
The primary is wound with 235 turns of the No. 16 D.C.C. wire. When the winding is finished bring the loose ends out to binding posts which make a good connection. Carry this scheme out in all electrical apparatus. Determine the proper polarity and direction of the finished coil after winding. The windings on these two bobbins will be in consecutive layers.

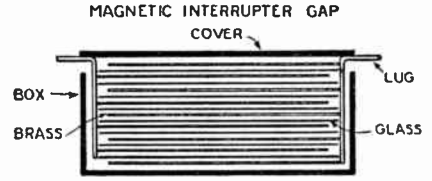
The secondary should next be made and this coil will require approximately 16,000 turns of No. 32 D.C.C. wire, which will require about 12,300 feet of it. Follow the proper direction of winding and bring the ends to the terminal posts. This coil must be likewise carefully built or else the transformer will blow. The turns must be counted accurately, and a revolution counter is here quite indispensable.

The bobbin and flanges are made out of fibre, cut to fit as required or may be of bakelite. Secure the flanges on the bakelite tube before winding.

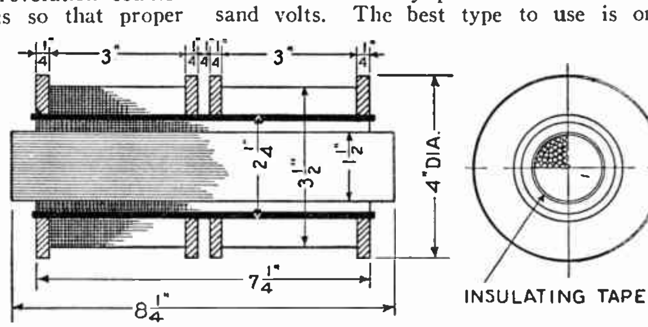
The primary spark gap should be of the quenched gap type, though even the ordinary type may be used and covered so that the light will not blind and the noise will not deafen. All experiments for glow effects must be performed in the dark hence the reason why a covered or quenched gap is desirable. The arcing distance on this gap will be somewhat short, this being due to the high capacity condenser being connected across the secondary. The gap should be adjustable for sparking distance.

The condenser which is used to help make the oscillatory discharge must be puncture-proof and high enough in strength to withstand the secondary potential of ten thousand volts. The best type to use is one composed of alternate sheets of glass as dielectric and No. 28 gauge brass. The size of the glass sheets may be about 10 x 12 inches and preferably as thin glass as you can get and it must not contain any bubbles. The brass plates will then be 8½" x 10½". These plates should be alternately laid one on top of the other until the entire condenser is assembled. The brass plates are




The spark gap used is shown above. It is glass inclosed. The diagram also shows a schematic sectional drawing of a high-voltage glass condenser.



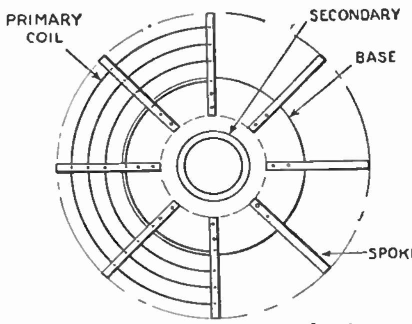

The power transformer is an important feature of the Tesla coil circuit. The one suggested by the author is of the cylindrical core type, its primary and secondary being wound on two separate bobbins, of similar size, not superimposed.

alternately connected so as to form a condenser with the glass plates as dielectric.

Use an odd number of glass plates and an even number of brass plates. About 25 plates of glass and 24 plates of brass give a very high capacity, and will give good results. A lower capacity may be used but the discharges will be less powerful. The condenser brass plates should all be cut so they have a lug on each and then the lugs are brought out to terminal posts. Place this condenser in a redwood box and wedge all in securely so the plates will not become displaced. This condenser when it is charged will give a bad shock if the body comes in contact with its electrodes.

The first transformer ratio you will note is 1 to 100. The same applies to the input to the Tesla transformer. Maintain this voltage ratio on any coil you may make in this line.

The primary coil of the Tesla transformer is now to be built and it is well to build it on the lattice work skeleton as shown in

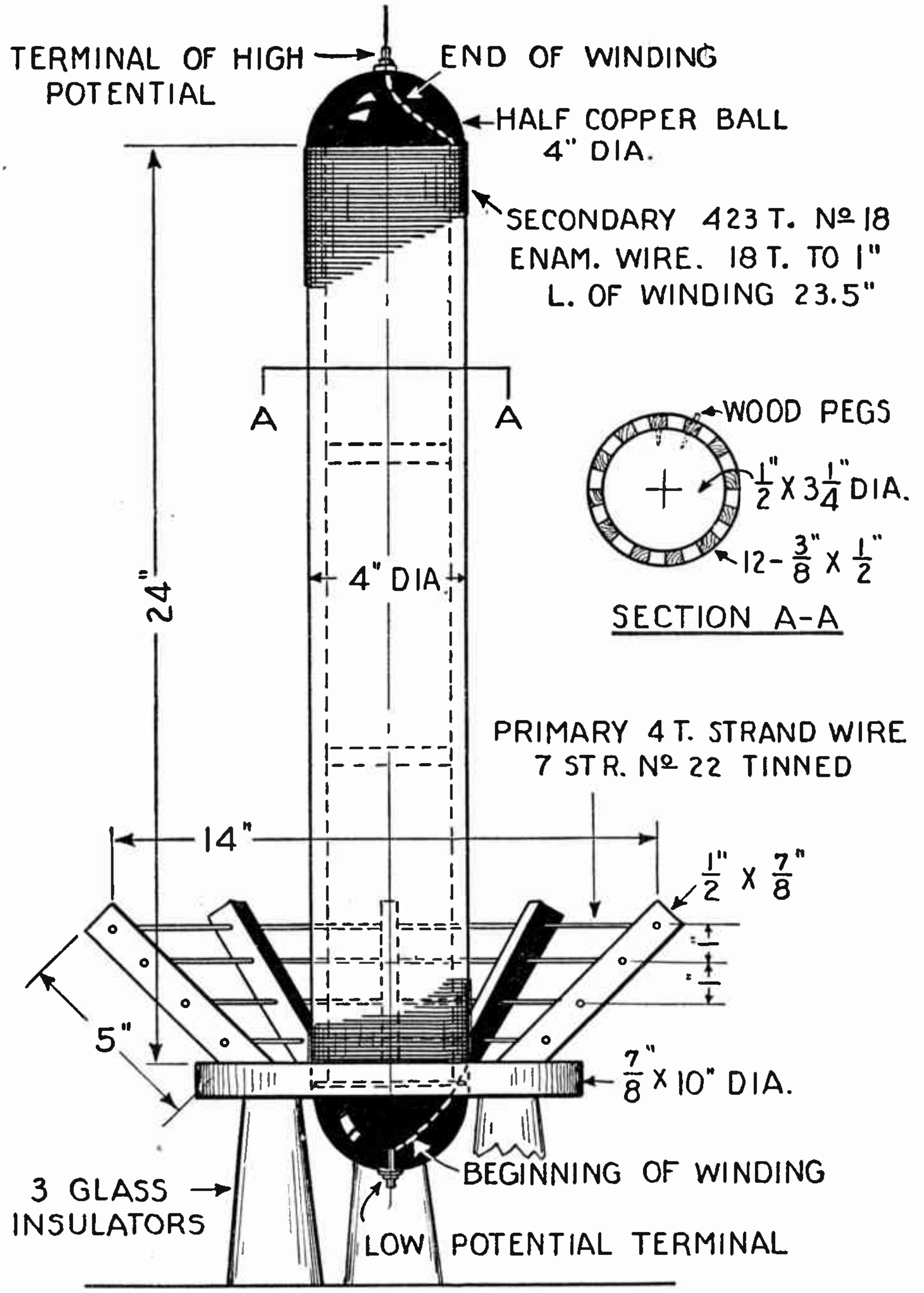



**Plan view of the Tesla coil showing radial primary supports.**

the diagram. However, bakelite tubing may be used in this particular part. From the results which have been obtained, it is perhaps best to use the wood framework. Make the coil truncated cone shaped inverted toward the base of the transformer. All wood used in any of this construction should be shellacked and of the redwood variety. The pieces should be all held together with pegs or dowells of wood and the wire is passed through the holes in each rib to secure the ends. No metallic object should be used in the coil or frame or else the coil will energize them and a brush discharge will occur. The base carrying the ribs that hold the primary should be 10 inches in diameter. Assemble all very firmly. Tinned copper wire with 7 strand No. 22 gauge wire may be used for the primary winding.

The secondary is carried by the wooden frame; bakelite or hard rubber tubing can be used. Make the frame of the dimension shown. Keep to these dimensions or reduce or increase in the same ratio. The tall sticks of the lattice work are likewise fastened with wooden pegs; four circular formers are necessary, the ones at the lower end should be made so that the secondary can be detached for portability. Electrical contacts are made at the bottom. The half balls of sheet copper on the ends of the secondary help the charge to accumulate and become dense. They are obtained at a metal spinner's shop and cost but little. See that the balls fit snugly on the ends. Make a binding post at the center extremity of each ball. Begin the winding on the secondary at the bottom and start winding toward the top. No. 18 to No. 22 enameled wire is used here. Wind very taut and determine proper direction in regards to primary and then solder the ends to the tips of the two copper balls. Keep the surfaces of the copper balls highly polished. When all assembly work is done wire up the Tesla coil unit itself.

Mount all the apparatus ona base of wood 3 feet long and 18 inches wide and shellacked thoroughly. In wiring allow sufficient clearance between all the apparatus. The whole




**Working drawings of the practical Tesla coil of simple and rigid construction. The secondary core or framework consists of 12 wood laths, cylindrically arranged and with copper hemispheres at the upper and lower ends. Note that the use of nails is avoided.**

group of apparatus can be set on top of long-necked jelly glasses, which are fine insulators. Be sure to keep the high frequency current from leakage to the ground or else the actual output at the top of the Tesla secondary will be small.

After final assembly the wiring to the house-line current should be made and the proper switches and fuses inserted in the line. A liberal use of fuses will prevent kick-backs through the house system.

A lower-powered coil may be made by substituting the supply of a parallel set of ¼ K.W. spark coils, in place of the large power transformer. This will give about 50 per cent. of the discharge obtainable with the large transformer. You may connect the spark coils on the A.C. 110-volt line, using a 500-watt flat-iron in parallel with them so the A.C. will not puncture their insulation. These two spark coils are the usual automobile ignition coils.

This improvised coil stunt is fine business for low power and it is well for one who wants to build one of the larger coils permanently to make one of the low power and determine the best positions, spacing, etc., of the apparatus. By this method one is enabled to incorporate all the experience into the larger coil when it is finally built. It is best for all who construct Tesla coils to experiment a bit with different makes of primaries and condensers, so as to obtain the best results. It is an individual problem to solve.

If any deviations are made from given dimensions, turns and size of wire, etc., it is well to carry out the same proportions, because these have only been determined after many types were tried and discarded in their favor. Insulate all parts carrying current thoroughly and wire all with a very stiff bus-bar wire so that there can be no short circuits.

The general layout and hook-up are given both for the transformer input and the spark-coil supply. Note carefully the fusing as employed, because some time a "kick-back" on the line may blow all the fuses on the house line. The choke should be wound on a 2" coil form and contain 250 turns No. 24 D.C.C. wire. The horn gap should be connected as shown and will aid in grounding any back line surge from the transformer. Note particularly all connections shown and

(*Continued on page 250*)

# Sensitive Galvanometer

### By David Terriere

THE galvanometer herein described is of the moving coil type and is very sensitive and accurate. In the moving magnet type the size of the magnets is limited and thereby the sensitiveness of the instrument is cut down greatly. This instrument, having a moving coil, enables the constructor to use a large and very powerful electromagnet, but the coil must be small to assure sensitiveness and quick action. In order to meet these requirements a wire of extremely small gauge is required.

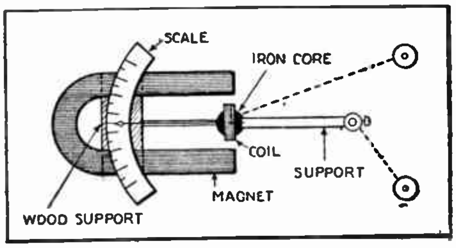



FIG. I

**Horizontal view looking downward upon the essential portions of a very sensitive galvanometer. A permanent horseshoe magnet supplies the field and a coil of No. 40 enameled wire moves the indicating needle.**

To proceed with the construction: The first necessity is a permanent magnet of the ordinary horseshoe type. This is shown in the illustration, and it should be bent on the flat instead of edgewise, as most magnets are. Such magnets are easily procurable. This magnet is mounted on a small wooden block, as shown, which block also serves as a support for the core and scale. The core is a small piece of cast iron and serves to concentrate the lines of force between the poles of the magnet. It does not move, being fixed to the base.

The core is drilled radially and the hole is tapped for an 8-32 thread. A small piece of brass rod is screwed into this hole, and the other end of the rod is fitted tightly into a hole in the wooden base block. The core should now be exactly centered between the pole pieces, as shown in the illustration. The magnet itself should be given a coat of enamel and then placed in the position shown in the drawing and clamped down with a strip of brass screwed down to the block of wood.

Now to turn to the construction of the coil. The form for this coil is made on a block of wood about ¾ inch square. A few layers of paper are wrapped on this form, which should be slightly tapered to facilitate the removal of the coil after winding. Two strips of paper should be wound parallel towards the ends of and over this paper to form a slot 1/16 inch wide and ¼ inch deep. Six or eight threads should be laid across this slot before winding.

The slot is wound full of No. 40 enameled wire in close, even layers over the threads, whose ends extend to right and left. Place as much wire as possible on the coil. An 8-inch length of wire should be left at both ends and the ends of the threads which were laid across the groove are to be tied to hold the winding together. The coil is removed from the form and wrapped with narrow strips of friction tape. The ends of the winding should then be brought out at opposite sides of the square coil. It should be given a couple of good coats of shellac and allowed to dry.

The support for the coil may be made by winding a No. 18 copper wire once around the coil and twisting together where one of the wires from the coil comes out. This piece of heavy wire should have one end about 2 inches long, and this is bent to the form shown. The end of the wire is sharpened to a point and rests in a small depression made in the brass arm which slides up and down the standard, and this is permanently fastened to the small copper tube, which has a set-screw to clamp it in any position. The depression in which the copper wire rests has a small drop of mercury placed therein to assure a good electrical connection. The pointer is placed in position by running it underneath this wire, where it is fastened to the coil proper. The pointer can be made of a piece of brass wire flattened on one end and touched up with a little black enamel.

On the opposite end of the pointer is mounted a counterpoise weight. This can be made easily by winding the wire in a close spiral, and, after the instrument is assembled, clipping off a short length at a time until the armature balances centrally on its pivot. The needle can be fastened by means of fine silk thread and shellacked to hold it stiffly in place. The next consideration is the scale, which is mounted on the magnet. It consists of a piece of zinc cut to the shape shown. A scale made of smooth white paper is center. Divisions on the scale may be made calibrated in degrees with the zero at the to suit the fancy of the constructor, but ten to the inch is usually sufficient.

The bottom lead wire from the coil is twisted into a spiral and soldered to a copper washer. A bolt is put through the center of the washer into the base and one connection is made to the screw. In adjusting the instrument, if the pointer does not rest on zero, it is merely necessary to turn this washer a few fractions of an inch in the proper direction until the pointer reaches the zero mark, and clamp it there by means of the nut. It would be advisable to make the baseboard large enough so that a glass bell jar can be placed over the galvanometer to protect it from dust and moisture.

Very few measurements have been given, as a great deal depends upon the size of the magnet available and upon what odd pieces of scrap are at the constructor's disposal. The details can be varied greatly if reasonable care is exercised to get the parts in the proper proportion.

The instrument is now complete and may be tested. It is well to remember that this galvanometer operates on very small currents, and powerful currents should not be used or the instrument will be burned out.

When powerful currents are to be measured, adequate resistance wire should be placed in series. A good method of testing the sensitiveness of this galvanometer is to take an ordinary half-dollar, connect one wire

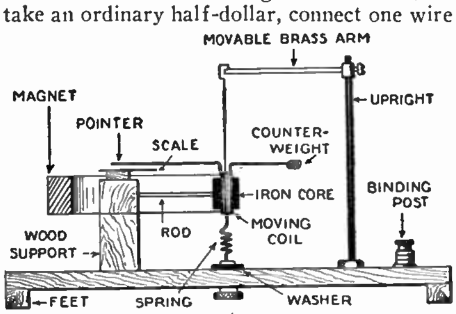


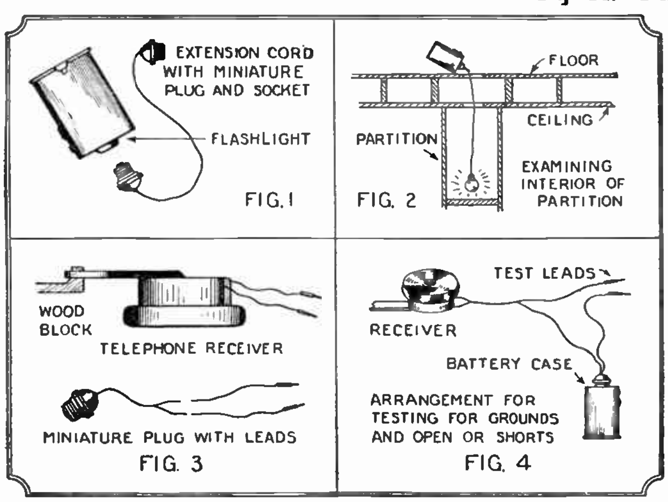

FIG. 2

**A side view in elevation and in section of the sensitive galvanometer. Here the counter-weight is shown which keeps the pointer horizontal.**

to it and lay a piece of flannel soaked in salt water on top of the coin. Now touch this flannel with a copper wire connected to the other terminal of the galvanometer. A deflection of at least half an inch should be obtained, which would indicate that the instrument is in excellent working condition.

# Some Testing Tips

### By H. Bushlowitz, E. E.




**Simple suggestions for the house-wiring electrician. A flashlight battery supplies a lamp through a long, flexible cord which can be dropped down into small places for examination, as shown in Figs. 1 and 2. In Figs. 3 and 4 is shown the use of a telephone receiver for finding grounds, open circuits and short-circuits. The telephone is attached to a block of wood to be held by the teeth.**

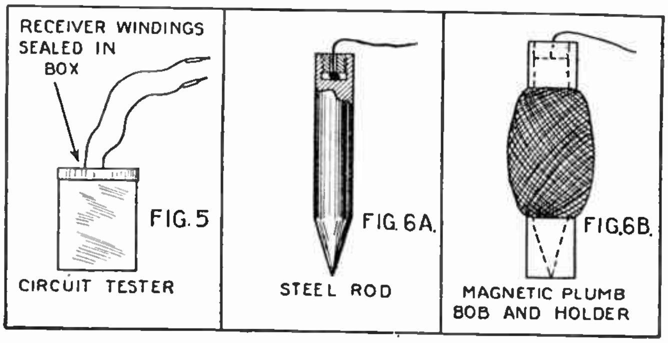
FROM time to time all kinds of electrical apparatus should be tested for trouble, phase outleads, etc., or to overcome difficulties in wiring. It is often possible to get along without special apparatus if a little ingenuity is employed, but it means a lot of lost time. It is entirely possible to test out circuits by connecting to the water and gas mains for juice, and use the receiver off a telephone for an indicator when nothing else is at hand; or standing on a dry board to find a blown fuse with the fingers. But why bother, when a few pieces of apparatus taking no more room than a small camera will save minutes and often hours on the job? Few electricians will have use for all the instruments, but they are handy for the man who has to drop his tools, roll up his sleeves and tackle anything from repairing a doorbell to wiring an apartment house.

The first requisite is a pocket flashlight. The small, flat, nickel-plated lamps are reasonable in price and can be slipped into the vest pocket. Alone it is rather limited in application, so for examining the interior of partitions obtain an eight-foot length of fine twisted wire fitted at one end with a miniature attachment plug and at the other with a miniature socket. The lamp can be removed from the flashlight, the plug screwed in and the lamp replaced in the socket at the end of the cord. The light can be lowered into partitions and such. Once used you would not part with it.

For testing circuits a telephone receiver is possibly the best indicator and the flashlight battery will serve as a source of current. Fit a set of three-foot leads with a miniature attachment plug, leaving the ends of the wire bare. The battery can be slipped into the pocket, one lead run to the telephone and the other leads from the telephone and battery acting as testing terminals.

A head-band takes up too much room in the kit, so recourse to the following scheme is had: A small block of wood is bolted to the ring on the receiver (as illustrated). By gripping this block in the teeth any "clicks" are plainly heard, partly due to the receiver being pointed to the ear and also to the vibrations carried through the teeth and bones of the head. This might be criticised on the point of being insanitary. The only protective measure the writer has used is to limit the use of the device to himself.

The usefulness of the above instrument is practically unlimited. For instance, extensive alterations were going on in a large building and a number of outlets were to be altered. The service being removed it would have been quite a problem to pick up live legs to tap in the extra lights without the above. The battery case was simply hung on the feeds to the panel, jumping the outside legs of the two-wire system together. It was possible to pick up wires by "going in" with telephone on different pairs in various parts of the building.




**The circuit tester is a box containing a set of receiver coils. A spark is drawn with them from any active circuit and the length of the spark gives a clue to its voltage.**

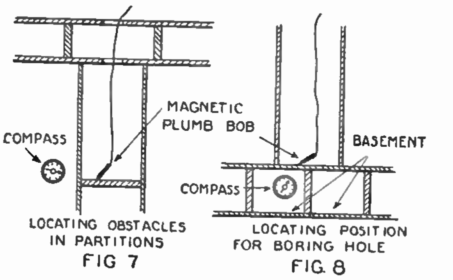
**In Figs. 6A and 6B is shown a magnetic plumb bob, its case and cord.**

So much for testing wiring. When it comes to locating open and blown fuses on power circuits two 110-volt lamps in series are usually employed. This is entirely satisfactory, but the lamps are bulky. If only sockets are carried, sometimes lamps cannot be obtained, while the little device described here is even less bulky than two medium sockets. The test was made by taking the windings from three 75-ohm, single-pole receivers and connecting them in series. The coils were then placed in a small, round, wooden box and 12-inch leads run through holes in the cover. The box was filled with melted sealing wax, the cover being firmly glued in place.

The testing is done by "flashing out," that is, holding one lead on one terminal and tapping the other on the other terminal of the circuit. This test set will pass about one ampere on 220 volts and half that on 110 volts. After a little practice the voltage can be readily determined by the size of the flash. The instrument should not be kept in the circuit for any length of time, or it will burn up. One of these has been in use nearly two years and is still working.

Another handy device is a magnetized plum bob. There are several makes of narrow steel plumb bobs on the market that can be magnetized and will serve the purpose. One 3 inches long and ½-inch in diameter is about right. If desired, it can be made from a steel rod by drawing the temper and drilling as shown in the illustration. The point is ground and the rod hardened. It can then be magnetized, either by rubbing on the poles of a direct-current machine of by enclosing in a coil of wire and passing a heavy direct current.

The bob, in addition to its usual purposes, is to be used in connection with a compass to locate outlets through the walls and ceilings and to show the positions of horizontal studs in a wall or partition. How it is utilized is to be seen in the illustration. Dropping it down the partition a compass is used to locate it. It thus reduces the wall cutting to a minimum and speeds up the work.




**How the magnetic plum bob is used to locate obstacles and to find how to pass wire in partitions.**

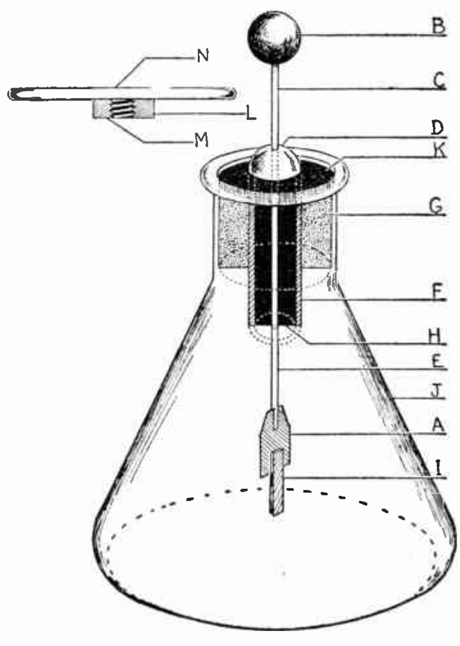
# Electroscope for Detecting Small Discharges

**By Hymen Bushlowitz**

A SENSITIVE electroscope is always a most useful, if not an indispensable instrument in the equipment of every laboratory. Use has generally been made of the electroscope in detecting and determining the nature of minute electrical charges. The same principle, however, has been applied to a method of measuring delicate potentials and, quite recently, to the detection of feeble radio-active bodies. Since the former application may more properly be termed an electrometer and the latter involves an apparatus beyond our immediate needs, a very sensitive type of the common gold-leaf electroscope will be the subject of this article.

The flask of the electroscope is an Erlenmeyer type; it has a capacity of about 21 cubic inches and a mouth of about 1⅝ inches diameter. Such a flask can be purchased for a small sum from some chemical supply house. It should be about 6¾ inches high and about 3¾ inches in diameter at its largest point. Two ¾-inch balls made of brass are required.

Drill a ⅛-inch hole to a depth of $\frac{3}{16}$ of an inch in one of the brass balls and saw the other in half. One of the hemispheres may be discarded, but the other must have a ⅛-inch hole drilled through its center perpendicular to its plane face. Tap both of these holes with a 10/32 machine thread. Care should be taken to protect the balls during the drilling and tapping so that their surface faces will not be marred. A piece of $\frac{3}{16}$-inch brass rod must be cut into pieces, one 2¼ inches long and one 3¼ inches long. The shorter one of these two rods must have both its ends threaded to a distance of $\frac{3}{16}$-inch with a male thread of the same gauge as that in the ball and hemisphere.




**A gold-leaf electroscope in an Erlenmeyer flask, whose shape adapts it especially for this apparatus.**

Thread one end of the longer rod similarly, and with a hacksaw cut its opposite extremity lengthwise to a distance of ¼-inch. Cut a rectangular piece of $\frac{1}{16}$-inch brass, ½x¾ inches, and insert the same longitudinally in the slit prepared in the brass rod and solder fast. After the superfluous solder has been removed with a file, the rectangular plate may be trimmed into shape, as shown at A.

Screw the ball (B) to one end of the short rod (C) and the hemisphere (D) plane face out, to its other end. The long rod (E) is screwed into the hemisphere, and now the brass must be polished well with ground pumice-stone and everything is shellaced, except the ball (B) and the plate (A).

Obtain a cork somewhat larger than the mouth of the flask and with the help of a sharp razor blade trim it so as to make a nice fit, finishing with sand-paper, care being taken that the fit should not be too tight for fear of breaking the thin-walled flask. Place the cork on a table and roll under a board, pressed by both hands, until it has become softened. Sand-paper its sides smooth and bore a five-eighths inch hole through its center with a cork-borer. Cut the cork to a length of about an inch. A piece of glass tubing (F) with a one-half inch bore and a one-sixteenth inch wall must be cut to a length of one and five-eighths inches long. This is inserted in the hole prepared for it in the cork (G), the upper end projecting one-eighth inch above the top of the cork. The long rod (E) is centered in the glass tube (F) so that the

(*Continued on page* 240)

# Experiments with a Rotating Field

**By George R. Larkin**

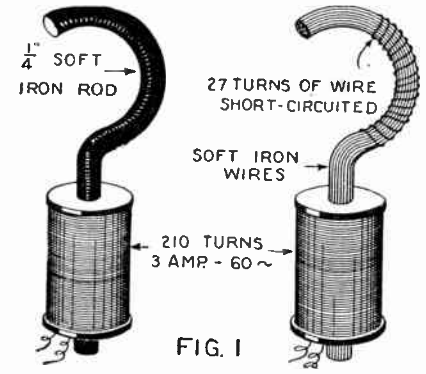



FIG. I

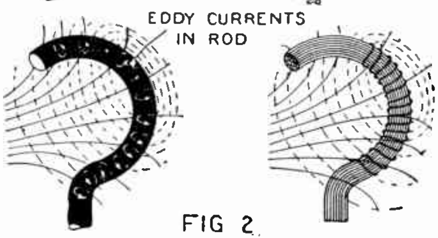



FIG 2

**Fig. 1 shows the mounting of a curved rod for showing the rotating field, and Fig. 2 gives the lines of force produced by eddy currents due to the alternating current.**

ONE of the most difficult phenomena of electricity for the amateur experimenter to understand is that of the rotating field. The phenomenon is not only difficult to visualize, but also presents experimental obstacles especially where the form of apparatus demands 2- or 3-phase current. As most homes are supplied with single-phase current, a set of experiments on the rotating field, which can easily and cheaply be made, are of particular value. While the apparatus described below is not a very efficient one, its simplicity more than makes up for this defect.

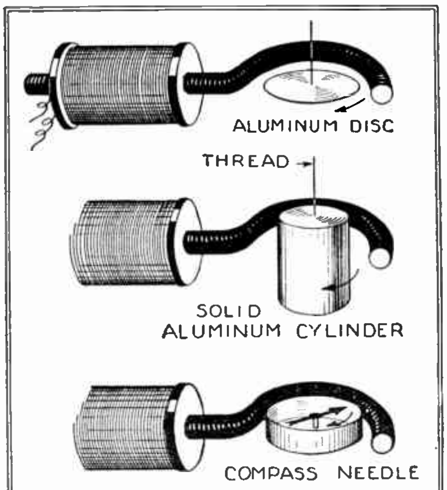



FIG. 3

**Fig. 3. These are experiments in the rotation of aluminum pieces and of the compass needle by the rotating field.**

Fig. 1 shows two forms of the device which may consist either of a solid soft-iron rod or a bundle of soft-iron wires bent into a semi-circle at one end and slipped through a spool magnet. If the built-up wire core is used it will be necessary to wind 27 turns of insulated wire on the hook as shown, joining the ends together and thus short-circuiting the coil. The spool magnet should have 210 turns and be supplied with a single-phase 60-cycle current of 3 amperes.

The explanation of the rotating field occurring in the hook area is as follows: Consider first the iron core. The magnetic lines of power sent through the iron by the magnet coil travel with infinitely great rapidity, setting up a field such as that shown by the full lines in Fig. 2. The passage of these lines of magnetic force through the iron, however, causes a series of eddy currents in the core which in turn produce a field, as shown by the dotted lines. This latter field is displaced 90° of phase with the former, that is, while the field caused by the spool magnet is decreasing, the field caused by the eddy currents is increasing; when it has disappeared the eddy current field is at its maximum and vice versa. This crossing of the fields at right angles and with a 90° phase difference causes the rotating field.

In the case of the built-up wire coil, no eddy currents are formed and it is necessary to use a short-circuited coil to induce the secondary field. The field caused by the coil is exactly similar to that of the eddy currents in the solid iron core.

The existence of the rotating field can easily be proved by some simple experiments shown by Fig. 3. The first sketch shows an aluminum disk, supported by a thread, set in rotation by the rotation field, the second a solid aluminum cylinder, and the third a compass needle. In all cases the rotation, shown by the arrow, is in the direction which the hook points. If the hook is rotated 180° the rotation will be in the opposite direction.

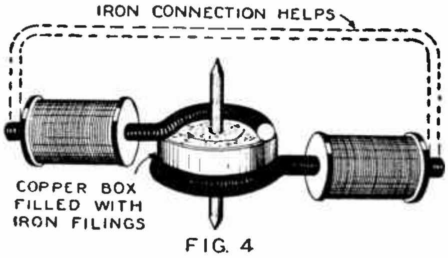



FIG. 4

**In Fig. 4, we have a cylindrical copper box filled with iron filings. It is mounted as indicated and rotates with great velocity.**

If two hooks are used as shown in Fig. 4, acting on an armature consisting of a copper box filled with iron filings, an asynchronous motor will result. Rotation will be augmented by joining the ends of the hooks with an iron rod, as shown by the dotted lines.

An extremely simple motor can be made, as illustrated in Fig. 5. Take two pieces of iron pipe of 3-inch and 1-inch diameter, fit two pieces of soft iron as pole pieces, then saw in two, as shown and tap for screws. The armature should be made of soft iron cut in star shape. Copper rods are placed in the V's and soldered to copper plates on the top and bottom. A steel rod forms the axle. Two brass strips screwed to the pole faces form the support for the armature. This motor is both asynchronous and synchronous. A much better motor will result if a field piece is cast to the form of Fig. 6 or cut from a block of soft iron. The stronger the field magnets are, the more power the motor will have.

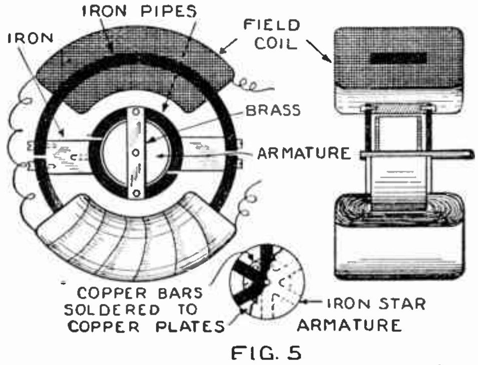



FIG. 5

**This shows a simple A.C. motor using what is known as an iron star-armature, to be operated by the rotating field.**

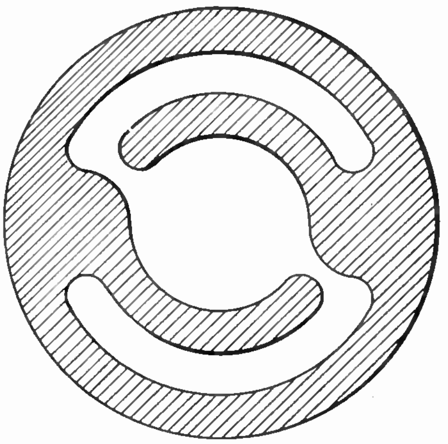



FIG. 6

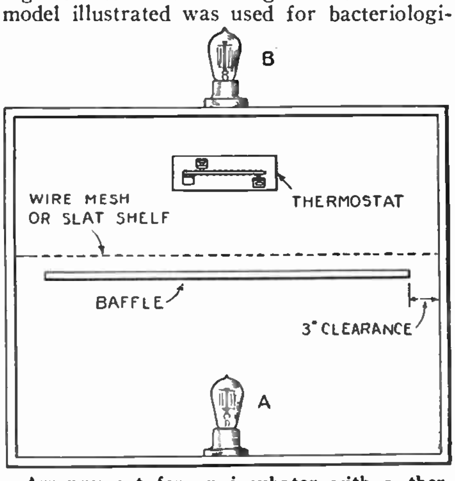
**How to have a cast iron field frame for the A.C. motor, or it may be cut out of heavy sheet iron.**

---

## Electric Incubator or Bread Raise

By Donald A. Learned

FOR the person who has need of an incubator or low-temperature oven, with automatic temperature control, the outfit herein described is reliable, simple to construct, and inexpensive to build and operate. It may be used in bacteriological or biological work as an incubator. It is suitable as a bread raiser or as an egg incubator, to name two more practical applications. It is also very suitable as a forcing box to test seed germination. The model illustrated was used for bacteriological work, but very little variation is necessary to adapt it to the other uses.

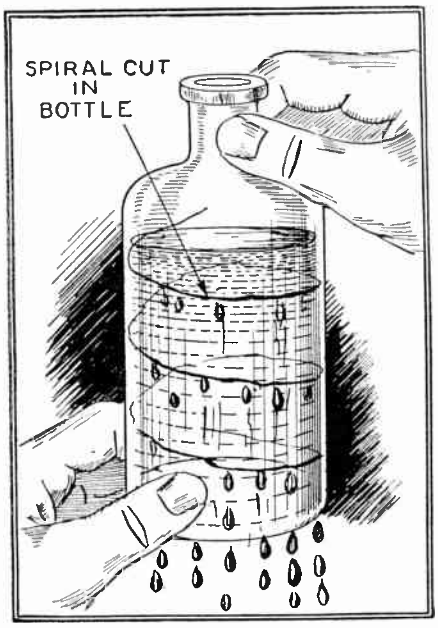



**Arrangement for an incubator with a thermostat, which will operate for hatching eggs, raising bread and the like. If for eggs, remember to turn them periodically.**

The diagram is almost self-explanatory. The incubator is constructed from a solid box, preferably of inch lumber, or it may be built of new lumber. The walls may be lined with any heat insulating material, or may be doubled, but neither scheme is necessary. Construct the incubator so as to have nearly twice the interior space needed to permit the installing of the heater and regulator. On the bottom inside is fastened a porcelain cleat-base receptacle. About 12 inches above the bottom, place a horizontal

(*Continued on page* 242)


## Spiral-Cut Bottle

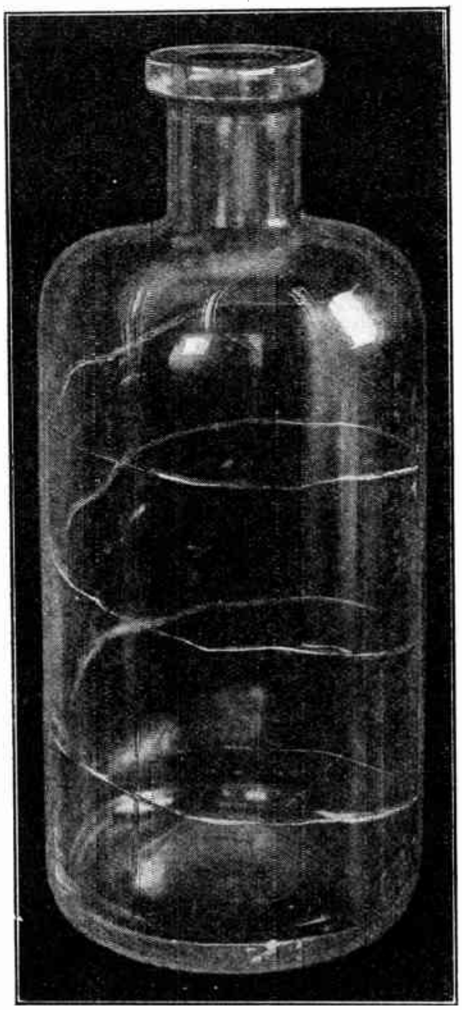



WE GIVE here the photo of a bottle which has been cut into a spiral. It is done in the following manner: With a file, a scratch (it need be little more) is made at the place about where the cut is to begin. By holding firmly against the file mark a piece of red-hot glass or, what is very convenient, a clay pipestem, heated as hot as a Bunsen burner will make it, a crack is started. It may require several applications and perhaps more filing, and if inclined to be very obdurate a piece of glass tube or glass rod may be melted until its end is soft, and then pressed down firmly against the glass so as to bed itself upon it. This is pretty certain to start a crack.

The result to be looked for is a crack, slightly irregular, and which may be an inch or two in length, and which will spread both ways from the original cut. Next, the pipestem or other object is heated a second time and drawn along the bottle while the crack is watched. It will be found that the crack will follow it closely, perhaps a little in arrears or a little in advance. When the pipestem gets too cold to work well, the crack will cease to extend. It is well to have two pipes, one to be heating while the other is in use.

From one to three inches of the cut can be got in one heating, or, with good luck, even more. The "good luck" feature depends upon the nature of the glass of the bottle. The pipestem is heated again in the Bunsen burner at a full red heat and, as it is a very poor conductor of heat, the hand which holds it never feels the temperature. The cut is now led on for a few inches more. In this way the bottle may be cut into a spiral; the bottle shown in the photo required perhaps fifteen minutes for its cutting.

When it is thus severed, it will hold water, there being a very trifling leakage. But if held by one hand at the top and the other at the bottom, and pulled apart, the crack will open a minute amount only and water will stream out of it. This is a good suggestion for a performer of magic. The bottle is merely a *tour de force*, as the French call it. It shows what a chemist can do in the way of cutting glass.



**Above is shown the reproduction of a photograph of a bottle which has been "cut" in a spiral from top to bottom. The cut is really a crack which was led in the desired direction by the use of a hot pipestem. It is a good example of what can be done in the manipulation of glass.**

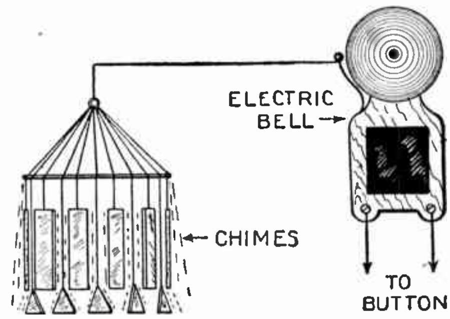
**Above to the left is shown how water can be made to stream out of the bottle by pulling the crack open a minute fraction of an inch.**

## Electric Chinese Chimes

THESE Chinese chimes can be adapted to use as a door-call by attaching them to the knocker on an electric bell, as shown in diagram.

They are very pleasing to the ear and you can find many novel uses for them. They may be used with or without the bell.

*Contributed by* LESLIE F. CARPENTER.




**The familiar Chinese chimes made up of strips of glass, suspended from a bar, are here made to give their musical tinkling when an electric bell is rung.**

## Simple Electric Furnace

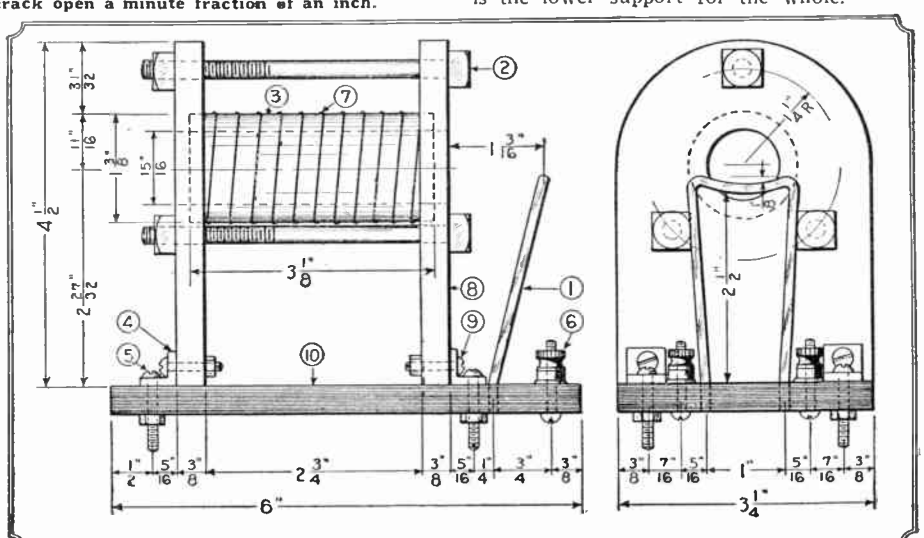
By P. B. WALLACE

A SMALL electric furnace which may be built by any experimenter at small cost is illustrated here.

The porcelain tube or heater element is removed from a discarded "bowl" type electric heater. It may also be purchased for about 75 cents.

Ninety-three feet of No. 24 B. & S. nichrome steel wire is wound on this tube and the ends anchored through holes drilled through it. The wires are then led under the base of the furnace to the binding posts.

The supporting ends and base are made of ⅜-inch-thick asbestos sheet. The ¼-inch bolts holding the heater together are 4 inches long. The bent piece of ⅛-inch iron rod is used to support the handle of a soldering iron when heating the latter. The base is bolted to the ends with small bracekts and screws and nuts. A slate or other slab of non-combustible material about ¾ inch thick is the lower support for the whole.



**A detailed drawing of an electric furnace for the production of low temperatures such as those used in heating a soldering iron, for which it is especially designed, although it can be used for tempering and the like.**

## Immortalizing Baby's Shoes

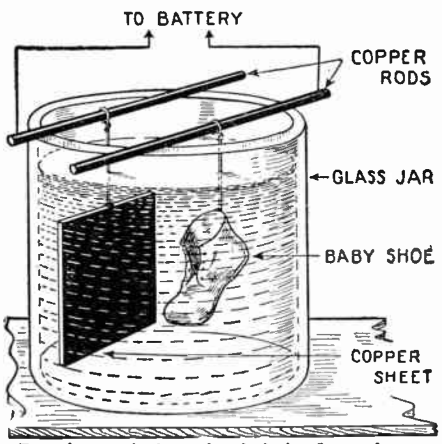
*By* Hyman Bushlowitz

THERE are five successive steps in plating the shoes: drying, water-and-acid-proofing the shoes, making the shoes conductive to the current, copperplating and silverplating, finishing, as buffing or polishing, and lacquering.

The drying can be done either in the air or in a hot air chamber.

The first operation is to make the shoes absolutely waterproof and acidproof. Unless this is done the solutions will penetrate and destroy the leather, thus spoiling the whole operation. First dip the shoes for about thirty minutes in a hot composition made up of eight ounces beeswax, 2 lbs. paraffin and 5 ounces resin.

Upon removing the shoes you will find that they are coated with a thin film. This is allowed to cool. The next operation is to give the shoes a thin coating of shellac and allow




**By electroplating the baby's first shoe, as shown above, sentimental mothers will be assured of its permanence. Any metal may be used with the proper electrolyte.**

them to dry in the air for about three hours. When thoroughly dry give them two coats of the following mixture: 3 oz. copper-plating ronze powder, ½ pint lacquer and ½ pint amylacetate.

After the shoes have been carefully and thoroughly coated, place them again in the air to dry. This usually takes from five to six hours. They are then ready to be copper-plated. Before the shoes go into the plating solution, great care must be exercised not to handle them roughly, for even fingerprints prevent the correct deposition of metal.

Now secure a 2½-gallon porcelain crock or glass jar, and pour in the following solution: 2 lbs. copper sulphate in 2 gallons water, and 6 oz. sulphuric acid.

Upon the crock place two brass or copper rods and connect them with the source of current. From one of the rods suspend one shoe in the solution, and on the other rod hang a piece of sheet copper about 6 inches square and ⅛ inch thick, using a copper wire to suspend each.

The rod that holds the shoe acts as the cathode and the piece of sheet copper as the anode.

The source of current employed may be from batteries and their amperage must be in the neighborhood of six or eight to the square foot of surface to be plated. The potential should be about one volt. Leave the shoe in this solution for about twenty-four hours, when a coat of 1/64-inch copper will be smoothly deposited upon it. Allow it to dry and then buff or polish it.

Some people prefer a different metal than copper. Brass is very attractive.

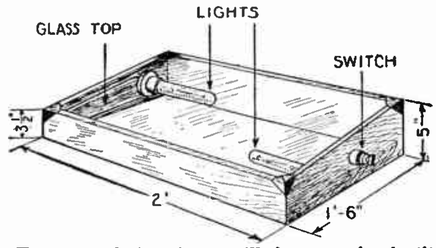
The following is the formula for brass: 6 oz. copper cyanide, 9 oz. zinc cyanide, 3 oz. hypo, 3 oz. sodium phosphate, 1 gallon water.

Brass-plating is done upon a previous copperplating and requires about one hour.

When the plating is finished and polished, it may be lacquered all over to prevent the metal from tarnishing. The shoes may be polished from time to time with an ordinary metal polish. A silver coating may be deposited on the copper

## Electric Tracing Desk

OFTEN, in the course of one's daily work, it is necessary to trace a drawing or blueprint, the lines of which, when covered with tracing paper, are almost invisible. Most likely, in a case like this, the drafts-



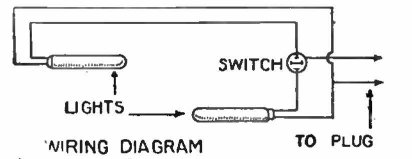

**Tracing of drawings will be greatly facilitated by the electric tracing table illustrated above. Two electric lights, mounted within the cabinet, produce a powerful illumination, which renders the tracing paper almost transparent. A ground glass plate will give more diffuse illumination.**

man has recourse to the time-honored method of applying the drawing to the window pane and tracing it there, as well as possible.

The difficulty of holding both drawing and tracing in place and the extreme fatigue of the arms experienced as a result, induced the undersigned to seek some means whereby the same result could be obtained without the accompanying discomforts. After a little scheming, the apparatus described below was evolved, with such gratifying results that I thought it well to pass the idea along for the use of anyone who may have occasion to do a good deal of tracing.

In the first place, a wooden box, without top or bottom, is to be made of the shape and dimensions shown. This may be only nailed together at the corners, or it may be neatly jointed, according to the ability of the operator. The wood should be about one-half inch in thickness. None of the sizes are hard and fast, but may be varied to suit the needs or convenience of the individual. The top should be rabbeted so as to hold a sheet of strong window glass. (Plate glass would, of course, be better. if available.) This may be held in place with small metal corner pieces which can be procured at any hardware store, and all that remains is to fix the electric lights which furnish the required illumination. Two porcelain wall sockets, one switch, some eight or ten feet of two-strand pliable electric cord with plug and two lights are all that are required for this purpose.

The lights and sockets are to be fixed in the position shown and the wiring applied in accordance with the accompanying wiring diagram. The light bulbs should be of the very long type of Mazda lamp, 12 inches




**A diagram of the electric current for a transparent illuminated tracing table.**

long by one inch diameter, preferably frosted. These can usually be obtained from the city electric companies or from the Edison Electric Company direct. The cost of these is about $1.05 each. No bottom for the box is needed, but if a sheet of white paper or cardboard is placed beneath, the reflection will materially add to the illumination and facilitate tracing. For the same reason the inside of the box may be painted white.

*Contributed by* August Jeffers.

## A Telephone Experiment

TWO phones are placed one or two feet apart on a table. These phones are connected, as shown in the diagram, with a battery and a switch. A third phone is placed half way between them, and this one is not connected to a battery.

When the switch is turned on and off a click will be heard, but it does not seem to come out of the phones on the sides, which are connected to the battery. It seems to come out of the one that is not connected to any circuit.

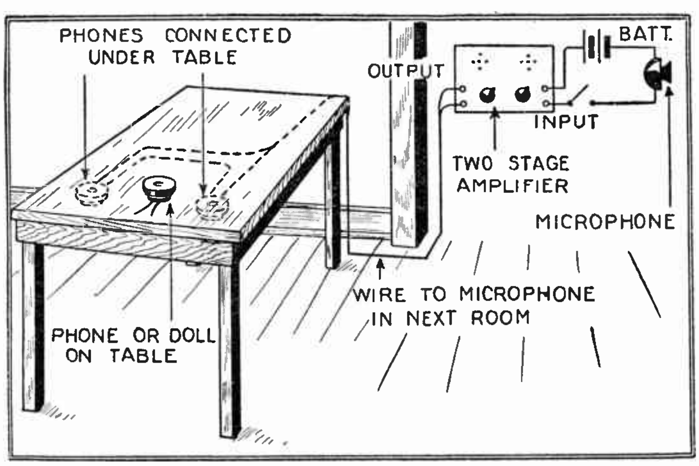
A doll is placed where the center phone was. The switch and battery is taken away and a microphone with one or two stages of amplification put in their place. The microphone is put in another room. If the microphone is spoken into the doll will appear to talk, although there is no connection with it.

Now, as to the explanation for this: When you hear a sound from a certain source we know, with some accuracy, where it comes from, because of the difference of the loudness of the sound in each ear. The sound is the loudest in the ear closest to the source. If the sound is the same in both ears you think of the sound as coming from a place directly in front of you. In this experiment the sound is the same in both ears when you face the center of the space between the earphones, therefore, you think the sound is coming from that place.

This experiment illustrates a phenomenon which could be made the source of considerable amusement. If the two concealed receivers are placed well apart, in the corners away from the spectator who is standing between them, the sounds will appear to come from between the two receivers. A doll mounted on a table with no wires going through it can be so made to talk to the mystification of the spectator.

Stereophony is used in Germany in broadcasting orchestral music and drama.

*Contributed by* Earl Jansen.




**Two hidden telephone receivers actuated by a microphone and amplifier will give the impression that the sound is coming from a source exactly midway between them. The experiment illustrates the phenomenon which has been termed stereophony.**

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

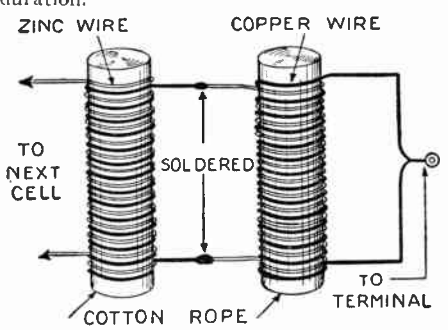
| First Prize, $25 | Second Prize, $15 | Third Prize, $10 |
|---|---|---|
| John Gordon | A. Chiocchio | Joseph L. Munzer |
| 312 N. Oxford, | 312 Roebling Ave., | 4313 Lancaster Ave., |
| Los Angeles, Cal. | Trenton, N. J. | West Philadelphia, Pa. |

### First Prize
### A Simple High Tension Battery

A SIMPLE high-tension battery of small current capacity, to be used for audio "B" battery and other experimental uses, is the goal of the battery experimenter.

Each cell unit in this battery is constructed by wrapping a zinc and a copper wire spirally around a length of cotton rope. The wires must not touch and are connected as shown. The closer they are wound to one another, the lower will be the resistance of the cell; the greater the number of turns of wire in the cells, the greater will be the quantity of current produced; the greater the number of cells connected in series, the greater the E.M.F. will be.

The chain of cells is now immersed in a battery electrolyte solution and left until the cotton ropes have absorbed sufficient electrolyte to furnish a current. The cells are then suspended in a tall glass jar, which prevents the electrolyte from evaporating readily and catches the cell drip. When the cells begin to fall in E.M.F. and current value, they are again immersed in the electrolyte solution until they pick up. I used dilute vinegar for an electrolyte. If one uses magnesium wires instead of zinc wires, plain water can be used for an electrolyte. Double cotton-covered copper wire and bare zinc can be used successfully, as the cotton absorbs the electrolyte solution and also spaces the wires, or both wires may be insulated. If the cotton rope is wrapped with a good capillary mass, such as burlap, the cells will last much longer in current duration.




**A very curious and interesting battery in which the electrolyte is absorbed by cotton or other porous material. It can be used as an "A" battery. The plates are represented by copper and zinc or magnesium wire.**

### Second Prize
### Silent Alarm

THE idea of this alarm, as it may so be called, is to awaken a sleeper without disturbing anyone else. It makes practically no noise, except indirectly, but the one who is awakened by it, unless he has unusual control of himself, will probably make remarks—at least, such is our judgment of human nature.

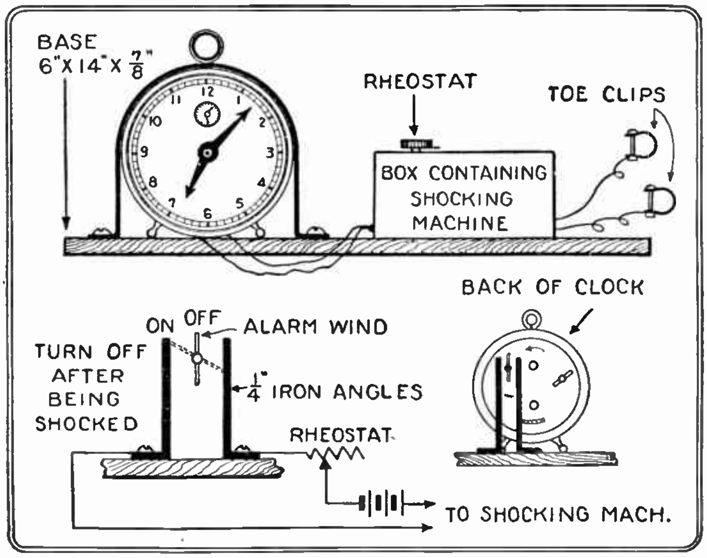
There are innumerable machines for giving electric shocks, and it is a simple matter to arrange for the closing of an electric circuit by an alarm clock. Shocking coil apparatus and electric clock alarms have been described very frequently in our columns. It will be understood that the gong alone of the clock will be removed, for the hammer will not make any noise of account.

When the desired time is reached, as determined by the alarm-set, the contact with the primary of the shocking coil is made, and the buzzer will start into action.

Wire leads from the secondary of the battery are connected to two light clamps, to be attached to the sleeper's toes. Then, when the clock reaches the hour at which it is set, either by the turning of the alarm winder or by the vibration of the hammer, it will close the circuit of the primary, which will at once begin shocking the sleeper and waking him noiselessly.

Another point is that the machine may be adjusted to give a lighter or a heavier shock, so as to be adapted to the soundness with which the sleeper courts his dreams.

**A silent alarm to awaken the soundest sleeper. A shocking discharge from a coil which is almost perfectly noiseless is given at a time determined by the setting of an alarm clock, so that no one else will be disturbed.**

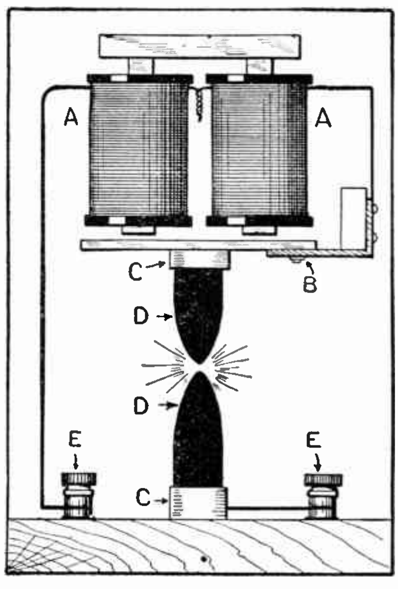



### Third Prize
### Home Made Arc Light

ELECTRIC bells are apt to be on hand in the household, or, if not, can be readily procured, and they involve mechanism available for the construction of the simple arc-light shown above.

The illustration is practically a description and speaks for itself. The bell magnet is to be rewound with No. 16 wire and is connected in series with two electric light carbons facing each other, as shown, tip to tip. They close the circuit. When the current is turned on, the magnet attracts its armature, separating the carbons and striking the arc from tip to tip.

Referring to the illustration, (A) is the magnet of the electric bell, rewound, as described, with No. 16 wire; (B) is its armature; (CC) are carbon sockets. The carbons are designated by the letters (DD) and the circuit is connected at the binding posts (EE). Connected with ten or twelve dry batteries, the lamp is said to give very good results.




**An electric arc lamp made with the parts of common electric door-bell. One carbon is carried by the armature directly in line with one below it, the magnet being inverted.**

### $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.

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

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

# What Our Readers Think

### An Experiment with Sodium Amalgam

*Editor,* THE EXPERIMENTER:

I submit the following account of an experiment which I accidentally ran on to while experimenting in the laboratory of the local High School which I attend.

While experimenting with a piece of sodium metal in the local High School laboratory, I accidentally dropped it upon the bench upon which I was working. It so happened that there was a drop of metallic mercury upon the desk and that the sodium metal fell into it. I reached down with a pair of tongs to pick it up, when to my surprise, it exploded with a loud report not unlike that of a flashlight cartridge. Instantly the two combined into a single drop which rolled around upon the desk, leaving a trail of burnt varnish behind. Suddenly it solidified into a hard amalgam of mercury. I carefully picked this up with the tongs and placed it in a beaker of water where it produced a reaction like that of pure sodium but much slower. I caught some of the gas evolved in an inverted test tube and found it to be hydrogen. After about three hours I noticed that the reaction had stopped and that pure mercury remained in the bottom of the beaker.

Upon further experimentation I found that the two could be made to combine by heating them together in a crucible over a Bunsen burner or by placing a small drop of water on the sodium.

This amalgam I also found to be very hard and brittle and slightly more stable in air than sodium itself; it must, however, be kept under gasoline or kerosene.

While the amalgam, itself, is of little practical value, the experiment is very fascinating.

Yours truly,
JAMES F. CORNELL.
Ashtabula, Ohio

*(We think your letter describes a very interesting experiment. The explosions you speak of are quite striking. The writer has met with similar instances of explosion with potassium while using it to evolve hydrogen in an inverted vessel by the decomposition of water; it had a great tendency to stick to the sides of the vessel and produce thereupon quite a violent explosion. The latter metal is a more unpleasant one to experiment with than sodium, for sodium is not usually guilty of violent reactions.*—EDITOR).

### One or Two(?) Ligntning Strokes

*Editor,* THE EXPERIMENTER:

I have been a reader of THE EXPERIMENTER (formerly PRACTICAL ELECTRICS) for more than the last two years. I am also a steady reader of *Science and Invention,* and of these two magazines, I must say that they are the best of all which deal with the experimental and elemental side of science.

You may be interested in learning that I have kept every copy of your magazine, from the very first to the last. I use them as an encyclopedia; but they have the distinct advantage of keeping up with science and not falling behind, as is the case with books. THE EXPERIMENTER is a wonderful improvement over PRACTICAL ELECTRICS, and it is getting better with each issue. I am especially interested in the *Radio Data Sheets* by Sylvan Harris.

Just now, while I was writing, came a most startling and abrupt interruption. The lightning, with a terrific crash of thunder, struck—where, I know not. Fire flew in every direction, and glaring cinders of something fell to the ground. The air was filled with a "metallic" smelling smoke. My radio antenna, or, rather, what was left of it, came down; investigation proved that about seventy-five feet of it had completely disappeared. The queer part of it, to me, at least, is that the farther end disappeared, while the grounded end was merely melted in a few places. I now find that the knife-switch, connected to ground the antenna, is so fused that it will not open. Lightning rods protected the house, or it probably would have been burned.

As a booster of THE EXPERIMENTER and *Science and Invention,* I remain, respectfully yours,
Pukwana, South Dakota. MERLE BISKEBORN.

*(We thank you for your appreciative words; you hardly realize how much such expressions mean to an editor. The description you give of the lightning stroke is most impressive, and we hope it will be read by our many radio friends.*—EDITOR.)

### More Suggestions

*Editor,* THE EXPERIMENTER:

Your request for an expression of why I am a reader of THE EXPERIMENTER and what I would like to see in the magazine enables me to say something I have had in mind ever since I have been reading it.

Before I saw THE EXPERIMENTER, I wrote to the *Popular Science,* asking them for information about any magazine that they knew of which handled a department of experimental chemistry in a popular way. They were unable to cite any such magazine. In other words, so far as I can see, the field you cover is unique in this department. Therefore, it would seem to me desirable to accentuate this one even more than you have.

I would like to see, also, a department of new chemical discoveries. History of how they were found, told in story form.

An up-to-date department on microscopy would be admirable and fill another unique field of magazines published in this country.

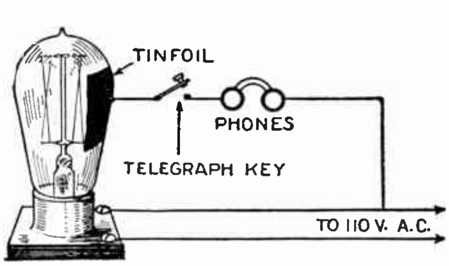
Yours respectfully,
WM. E. PALMER.
Los Angeles, California.

*(We consider our chemistry department as unique, and your letter goes to confirm our belief. We wish that we were able to carry out your valued suggestions, but our space is limited.*—EDITOR.)

**These columns are reserved for *YOUR* opinions. Do not hesitate to communicate your comments and suggestions regarding THE EXPERIMENTER. —EDITOR.**



### A Variation in a Code-Practising Connection




*Editor,* THE EXPERIMENTER:

I tried out the code-practising hook-up as it is given on page 102 in the December issue. Accidentally, I had my one hand on the metal of the key and with the other hand touched the cap of the phone and a severe shock was the result. This cannot happen with my hook-up and the tone is the same in either case.

I thought that on account of this difference you might be able to use this suggestion.

Yours truly,
Inwood, West Virginia. CLARK MILLER.

*(Your variation is certainly very interesting, and we take pleasure in giving it here. We always welcome such criticisms. Be sure to put your key on the grounded wire line.*—EDITOR.)

### More Chemistry Wanted

*Editor,* THE EXPERIMENTER:

Enclosed you will find my subscription for THE EXPERIMENTER for two years.

I think this is the best magazine I ever read, and I look eagerly for it each month. I am especially *interested in chemistry and would like to see more of it in the magazine.* The editorials are very good and I always read them first. The stories are just the kind I like to read, and all other departments are of a very interesting nature.

Cordially yours,
LEONARD G. YOCUM.
Douglasville, Pennsylvania.

*(You evidently appreciate the importance of chemistry at the present time. It is developing wonderfully, and is fairly revolutionizing our life. Everyone should read chemistry. It is a more interesting topic than a novel can supply.*—EDITOR.)

### A Reader of Many Years' Standing

*Editor,* THE EXPERIMENTER:

I thought I would write and add my word of appreciation to the fast-growing list which you, no doubt, have by this time.

I was a reader of *The Electrical Experimenter* in its day, and still have on file about twenty copies of it.

The PRACTICAL ELECTRICS was my next love, but I was glad when you enlarged it to include the other departments of Chemistry and Radio, both of which I am interested in, and changed the name to THE EXPERIMENTER. I have not missed a copy and trust from "the bottom of my heart" that I will not miss one.

Yours for the greatest of success,
HAROLD S. WILSON.
Sterling, Kansas. Reporter No. 15286.

*(It is very interesting to hear from one who has followed up* THE EXPERIMENTER *and its predecessors. We receive so many pleasant letters and so few "brickbats" that we feel much favored by our readers.*—EDITOR.)

### Articles on Physics Wanted

*Editor,* THE EXPERIMENTER:

Allow me to congratulate you on the re-birth of THE EXPERIMENTER. The clear and concise style of the articles are a great credit. THE EXPERIMENTER is an ideal work for amateur experimenters, and should be in the hands of all. I should like to see more articles on Physics, as they play an important part in the fields of science.

Wishing you every success, I remain,
Yours sincerely,
London England. R. G. TEMPLAR.

*(We are endeavoring to please the maximum number of readers, even if we have to use calculus and the higher mathematics to figure out our editorial policy. We appreciate your suggestion, and it may bear fruit in the future.*—EDITOR.)

### What an Ardent Reader Says

*Editor,* THE EXPERIMENTER:

I am an amateur chemical and electro-chemical experimenter and I find your magazine, which I have read since it was rechristened, very helpful; almost as much, in fact, as a set of reference books.

I would suggest, however, that your *experimental chemistry* and *electro-chemistry* departments be enlarged and that the latter be published more often.

An ardent reader,
Nashville, Tennessee. E. LEON FOREMAN.

*(We would be delighted to give more chemistry, but other readers want more electricity, or more radio, so the best we can do is to average. No such department as ours of illustrated experimental chemistry is published in any other magazine.*—EDITOR.)

### "The Cat's Pajamas"

*Editor,* THE EXPERIMENTER:

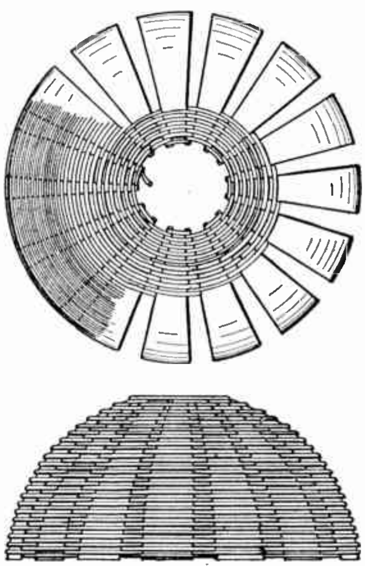
I just want to let you know that in my opinion the last issue of THE EXPERIMENTER (July) was "The Cat's Pajamas." However, I still think that there is too much valuable space devoted to Experimental Radio. The *Arc of the Covenant* is as good as ever.

Sincerely yours,
HENRY STONE, JR.
Bogota, N. J.

*(We presume the expression, "The Cat's Pajamas," is an approving remark. We do not agree with you about the radio department—but we do wish we had the room to expand all the other departments, which, as you can see, is an indirect way of accepting your criticism. You will have to say farewell to* "The Ark of the Covenant;"

# Latest Electrical Patents

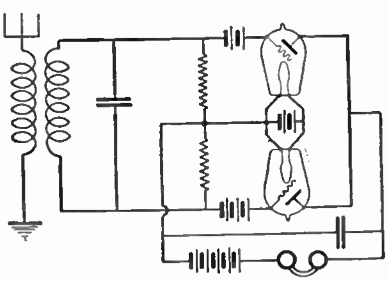
## Hemispherical Coil



By cutting pasteboard or other flexible material to the shape indicated above, and winding with wire, shortening the wire from center to the periphery, the paper is drawn into a hemispherical shape and the desired hemispherical coil is produced.

Patent No. 1,546,424 issued to M. M. Wood, Berwyn, Ill.

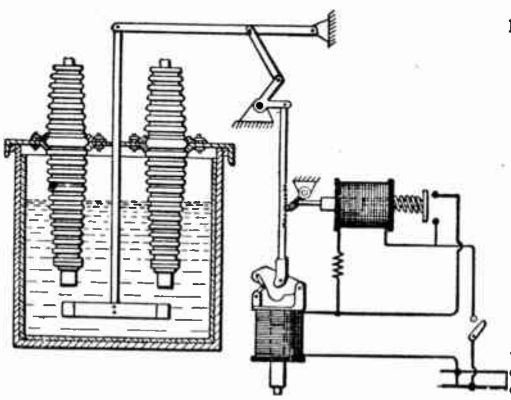
## Push-Pull System



By the arrangement indicated, the inventor claims to increase the efficiency of operation of a radio set considerably. The invention was particularly designed for use in connection with the control of signalling circuits, such as telegraph circuits.

Patent No. 1,544,939, issued to J. C. Schelleng, E. Orange, N. J.

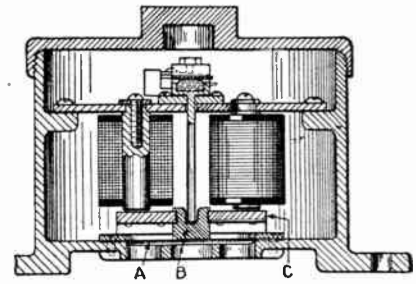
## Oil-Immersed Switch



To prevent an oil switch closing after it has broken the circuit, so as perhaps to re-establish a short-circuit with disastrous results, a pawl operated by an electromagnet is arranged to keep it open until the operator re-closes it.

Patent No. 1,548,800 issued to J. D. Hilliard, Schenectady, New York.

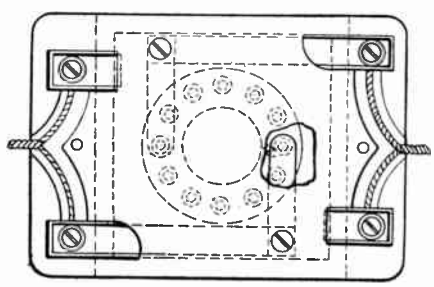
## Inclosed Diaphragm Buzzer




The invention employs a completely inclosed buzzer in which the armature (C) carries a hammer button (B) which is arranged to be normally in contact with the diaphragm (A). The buzzer is rendered more audible by an open lattice-work at the bottom.

Patent No.1,516,260, issued to F. W. Wood, Montclair, N. J.

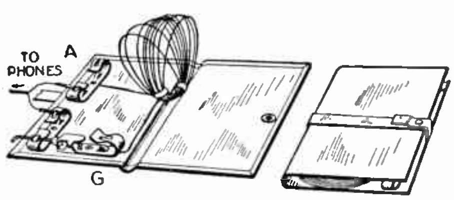
## Multiple Safety Fuse



The general idea of this device is to have a number of fuse wires arranged in a circle. The connections are made so that various lines can be protected and by opening covers over the circular member fuse wires can be quickly introduced.

Patent No. 1,548,111 issued to E. Antinoro, Rome, Italy.

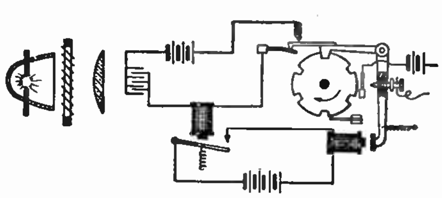
## Vest Pocket Radio




The invention provides a tuning inductance readily constructed and varied by means of a clip which regulates the degree of coupling between the turns. A crystal detector is easily embodied in the set, which latter when closed has the form of a small book.

Patent No. 1,544,754, issued to H. M. Hill, Leonia, N. J.

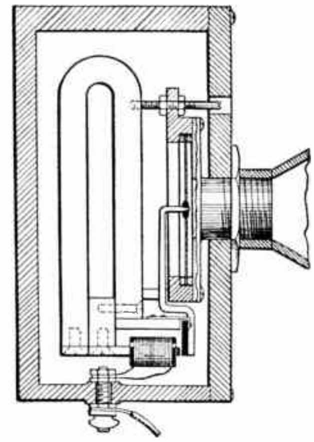
## Light Wave Control



The drawing shows a light source at the left with an adjustable shutter followed by a condensing lens. Immediately in front of the condensing lens is the selenium cell or other light-sensitive apparatus. The light affects the cell, the current going through it increases, and one effect is to open the main circuit by an auxiliary circuit seen below the main apparatus. This restores the activity of the cell and gets rid of lag.

Patent No. 1,548,811 issued to J. H. Hammond, Jr., Gloucester, Mass.

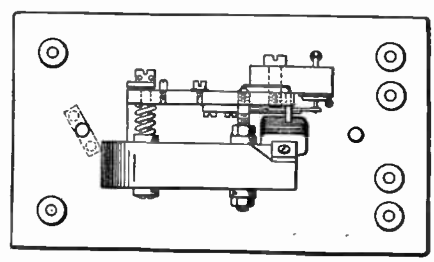
## New Loud Speaker



The invention provides a positively located and a more or less balanced armature. The magnetic attraction on the armature, it is claimed, will not cause an undue tension in the diaphragm.

Patent No. 1,544,653, issued to H. Koester, Waterbury, Conn.

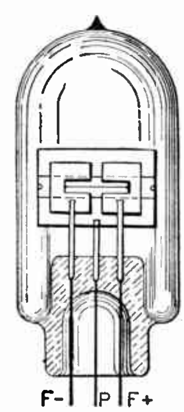
## Microphonic Relay



An electromagnet is provided with a vibrating reed which is shown directly over the magnet poles; the right-hand vibrating end of the reed is connected to a carbon plate in a microphone so as to transmit vibrations of the reed thereto for amplification. The microphone is shown directly over the framework which carries it and the reed.

Patent No. 1,546,470 issued to S. G. Brown, North Acton, England.

## Two-Element Electron Tube




By increasing the relative surface areas of both cathode and anode, which gives in effect condenser electrodes, impressed radio frequency oscillations are rectified and electrostatically modulate the electronic discharge between them. Much greater sensitivity is claimed as the amplification characteristic is augmented.

Patent No. 1,525,049 issued to S. Ruben, New York, N. Y.

# SHORT CIRCUITS

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

"Attractive" was the end
Of John P. Vontella;
A fork full of hay
He used for an umbrella.
—*Harold S. Wilson.*


Burned to a crisp
Was Joe L. Migar;
He tried the arc
For lighting his cigar.
—*William H. Cox.*

Drowned like a rat
Was John Herby Cole;
Lightning struck a locust tree.
Near the ol' swimming hole.
—*Harold Martin.*

Mercenary was the end
Of Montana Van Clime;
He reached under the third rail
To pick up a dime.
—*B. Catherton.*

**AUTOS SLIGHTLY DAMAGED BY FIRE**

Paul J. Heteji of 416 East Second street, called the fire department to his place of business at 9:31 o'clock this morning to extinguish an automobile fire caused by a short-circuiting of wires. There was slight damage. The car was standing outside of a garage when the fire occurred.

At 9:45 o'clock the department was called to the home of Pasquale Parretti, 346 East Third street, where a heated iron had set fire to the cloth covering of an ironing board. The blaze was quickly put out without much damage.

**UMBRELLA HITS LIVE WIRE, HOLDER BURNED**

BOSTON. — Standing with an umbrella over his head on the platform of the Green St. Station, of the Boston Elevated, William Bacher, 12, suddenly felt a sharp pain in the hand that held the umbrella. Unable to release the umbrella, the boy whirled around with pain.

The hands of the lad were burned. Evidently the umbrella came in contact with a live wire.

**ELECTROCUTED BY NAIL.**

LEXINGTON, Ky., Oct. 17.—Holding a nail which he drove through a board into an electric cable, Henry Shuman was electrocuted.

Sad was the fate
Of Philomeno Dispenser;
In his haste, he forgot
The series condenser.
—*Rigby Valliant.*

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


THIS department is conducted for the benefit of everyone interested in electricity and chemistry 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.
3. 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 50 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. When referring to magazine articles, always state the volume and page number.

## Double Tesla Coil

(565) Paul G. Heiselman, Randolph, Ia., writes:

Q. 1. In the December issue of THE EXPERIMENTER there was an article on a double Tesla coil, but the dimensions of the choke coil were not given. The little rod that comes from the center of the coils is not described, nor is there any connection to it shown in the hook-up. What is it, and what is it made of? How are the primary and secondary coils connected to each other?

A. 1. The little rod you refer to may be made of brass or copper. The spark between the terminals is due to E.M.F. induced in secondary coils by the primary; the two are not connected together. In the lower illustration on page 97 you will find the connections shown; the rods are connected each to its own secondary and the secondaries are in series. It is not an easy matter to construct an efficient Tesla coil. You will find other coils of simpler construction described in a number of issues of THE EXPERIMENTER and of PRACTICAL ELECTRICS. For any further information as to Mr. Branch's coil, you might address him at his Chicago Institute of Engineering.

## Mercury Vapor Lamp

(566) Edward Ross, Chambersburg, Pa., asks:

Q. 1. Is there any danger in handling and constructing a mercury vapor lamp according to your instructions in several numbers of THE EXPERIMENTER? Also, is there any danger from mercury vapors if you use a copper shield over the place where they may escape? Is a pair of colored glasses sufficient to keep the ultra-violet ray from harming the eyes?

A. 1. There is little danger in the work on a mercury vapor lamp, although in a factory where these lamps are made in quantity, some people are affected. We would not advise you to trouble yourself with the use of a copper shield. If the glasses thoroughly cover the eyes they will protect them, but you must take care, of course, that there is no leakage around the glasses. The skin is also affected as if by severe sunburn.

## Edison Primary Cell

(567) Irwin L. Arlt, Brooklyn, N. Y., asks:

Q. 1. Can you tell me if there is a cell made that corresponds in action to the Leitner Cupron Element? It is an electric cell using a copper oxide block and a plate of zinc in a solution of caustic soda.

A. 1. What you specify describes the Edison primary cell. In these cells the copper oxide acts as a depolarizer by being reduced to the metallic state, and the metallic copper thus produced acts as a negative electrode. They make an excellent open circuit battery, as they stand without deterioration; their voltage is low, however—less than a volt—but this is compensated for, to some extent, by their low resistance. They are used a good deal on railroad work for operating block signals.

## Tungar Rectifier

(568) F. R. Albrecht, Winter Hill, Mass., writes:

Q. 1. On page 480, first column, of the May issue of THE EXPERIMENTER, there is an article, "Tungar Rectifier." While for one who understands this subject, the article is plain, to me it is Greek. How are the terminals connected? How is the charger mounted? How can I tell when it is charging the battery? Can a novice make it, or would it be cheaper and safer to buy a factory-made charger?

A. 1. The terminals indicated in the cut in the May issue which you refer to, by arrowheads, are connected to the two wires on an A.C. house circuit. To know whether and how fast the Tungar is charging the battery, you may connect an ammeter in series. The illustration shows, however, a special case and quite an interesting one. You cannot make one. Buy a factory-made one, which is mounted in a case ready for use.



## Wimshurst Machine

(569) Leo Livada, Syracuse, N. Y., writes:

Q. 1. In the May issue of THE EXPERIMENTER, and under headline, "Experiments With Static," you say that a hard rubber comb can be charged by the Wimshurst static machine so as to give a blue flash when grounded, and I wish to ask, would the same comb, after being charged, be sensitive to magnetism; or could any other transparent, or liquid body be charged by the same static machine and be sensitive to magnetism? Would you let me know more about this Wimshurst machine?

A. 1. No magnetic effects can be developed in the method you specify. We have published a description of a Wimshurst machine in our issue of August, 1924, of PRACTICAL ELECTRICS, page 576.

## Radio Waves

(570) Arthur H. Avery, Alberta, Canada, writes:

I would be very glad if you would please publish the answers to the following questions:

Q. 1. Do radio waves pass through everything, such as a vacuum, buildings, or even the human body? I have been asked about radio waves passing through the body when a station is broadcasting.

Q. 2. Why is oil injurious to the wires on a generator if oil is an insulator?

Q. 3. Is it correct that rain can be made to fall by the use of electrified sand, and how is it done?

A. 1. Radio waves pass through organic substances, but are affected a good deal by metal, such as iron-frame buildings.

A. 2. Oil injures the insulation of the wires by softening it, so as to make the windings loose, whereas, they should be held firmly in place.

A. 3. Some very interesting experiments have been done under Government auspices in the use of electrified sand for effecting rainfall. We refer you to issue of *Science and Invention* of April, 1923, page 1154.

## Step-Down Transformer

(571) Michael Boscoe, Waterville, Me., writes:

Q. 1. I have a 220-volt, 3-phase motor that uses 3½ amperes of current. I would like to make a transformer to use this motor on a 110-volt, 60-cycle circuit, a step-down from 220 volts or 110 volts.

A. 1. Your motor figures out at about one horsepower, or a little more. For your 3½-ampere current you can use No. 14 or 15 wire. This is for one side of your coil. For the other winding, No. 13 wire will be quite sufficient to carry the 7 amperes. You will need, of course, half as many turns on your primary as on your secondary, as you want a step-down transformer.

It would be somewhat expensive to make exact calculations. You will find described in THE EXPERIMENTER of June, 1925, page 543, a somewhat larger transformer than yours, but extra size is a good thing in such apparatus. Another transformer is described in THE EXPERIMENTER for September, 1925. A tapped transformer is also given in the June issue, referred to above.

## Rectifiers

(572) C. Johnson, Jerome, Idaho, writes:

Q. 1. I wish details of construction of a vibrator-type charger for a storage battery.

A. 1. We have already published a number of such rectifiers. You will find them described in PRACTICAL ELECTRICS, July, 1922, page 359, and March, 1924, page 261.

The great point is to have the natural period of vibration of the armature so short that it can react in synchronism with the cycles of the circuit.

# The Experimenter's Bookshelf

## Phenomena Attributable to Ether

ETHER AND REALITY. By Sir Oliver Lodge, F.R.S. 179 pages. George H. Doran Company, New York, 1925.

Professor Lodge is nothing if not picturesque. In others of his books are treated decidedly recondite subjects; those who are at all familiar with them know what the book called "Raymond" is about, where his views on spiritualism are announced in the most explicit way. Here we have the ether treated; we do not know if ether exists and a glance at his preface suggests at least that he is steering a course pretty close to his "Raymond." He says that he uses the spelling "etherial" or "etheric" instead of the usual "ethereal," because he deals with the ether as a substance of physical properties. His views on spiritualism increased his notoriety and he added to this by lecturing in this country on that subject.

Throughout the book we find a comforting feature, or rather, one which must be comforting to the author, of being very sure. This personal certainty about things is quite a characteristic of Professor Lodge. Some of us, however, think that a little healthful doubting brings us nearer truth. Speaking of locomotion, he says there is no locomotion about a spinning top, that it is stationary. Most of us think that, when a top is spinning, it is far from stationary.

## Atomic Structure, Electrons and Nuclei

ELECTRICITY AND THE STRUCTURE OF MATTER. By L. Southerns, M.A., B.Sc. 128 pages with index. Oxford University Press, London, 1925.

This is one of the very attractive Oxford University Press monographs. We have already had the pleasure of reviewing several of these little books, and this one we find to be certainly most attractive. A very commendable and valuable feature about it is that the author does not hesitate to treat simple elements of the subject. It is not so easy to do this in science; it takes a specially good man to carry it through, and Professor Southerns seems to have succeeded particularly well in his attractive little book.

There is a glossary of a few terms only and we cite one of them: "Alpha-rays; consist of positively charged particles (helium nuclei) emitted by radio-active substances." It is positively refreshing not to be told, as we have been so often, that alpha-rays are composed of helium. A page is given to a select list of books, which follows out the good principle of naming the publisher as well as the author. A very full index is given, something which always pleases the reviewer.

## Popular View of Chemistry in Our Lives

CHEMISTRY AND CIVILIZATION. By Allerton S. Cushman, A.M., Ph.D. 171 pages with index. E. P. Dutton & Co., New York, 1925.

A book which treats on chemistry in practical life has so good a basis for its text that it cannot well be other than interesting. This book is written for the public and for the general reader, rather than for the strictly professional man, but it is excellent reading, even for the last; it is given a strong personal touch by frequent allusions to the work of scientists. Fuornier d'Albe, some of whose work we have already had the pleasure of reviewing in these columns, seems to be one of our author's favorite authorities. Einstein appears rather to worry him, as, unfortunately, he worries many others. Those whom de does so affect are not always prepared to acknowledge it.

The idea that a person is of one height in a day-coach and another when reclining on a Pullman, seems to make a pretty stiff draught upon one's credulity. You are practically told that you are one height in your bed at home and another when sleeping in the aforementioned Pullman. But this is no place to speak of Einstein. We have noticed one mistake, at least, in the index, and his formula for camphor, given on page 74, is open to amendment. But we do advise the reading of this book to show how interesting chemistry can be.

## Electrical Requirements in House Wiring

HOUSE WIRING AND BELL WORK. Compiled under the direction of William S. Lowndes, Ph.B., IV. 87 pages. International Textbook Company, Scranton, Pa., 1925.

The town of Scranton, Pa., is noted for its great correspondence school, and this little manual, in one way or another, bears the aspects of the correspondence school manual, both in typography and illustration. House wiring is a very definite thing now, because the legal and underwriters' requirements are very precise. So many fires have been caused by defective wiring that any number of restrictions are placed upon the work by the insurance companies, and unless you fulfill these requirements the house cannot be insured.

Some of the pages seem to have been reduced from large engravings, with the result that it takes a microscope to read them, unless one's sight is abnormally good. The numerous illustrations add greatly to the value of the book and cover the ground in an unusually satisfactory way. The author is the director of the Department of Architecture and Building Construction of International Correspondence Schools, so he speaks *ex cathedra.*

In one place at the beginning of the text we find the caption Part I, and from the preface we understand that there is a Part II, although, in the absence of a table of contents and index, we have not succeeded in satisfying ourselves as to where Part II comes in. Perhaps Part II is in another volume.

## More About Wireless

RADIO FOR EVERYBODY. vii, 361 pages with index. By A. C. Lescarboura. Scientific American Publishing Company, 1925. $1.50.

It is impossible to review at all adequately a book on radio of the extent of this one, with its numerous illustrations. It is pre-eminently a popular treatise and goes into details and to the very elements of the subject.

Any inclination we might have to criticize the book would be based on a technical criticism, whereas it is intended absolutely for the public. So the very elementary features of its text are what lay the foundation and a good one for the higher developments.

The author seems to have reached an excellent porportion of elementary and advanced treatments and never seems to lose sight of the idea that the book is to be a readable one and is to be read as well as studied. We are very certain, too, that many who consider themselves well advanced in the science of wireless reception could learn a great deal from this work.

The broadcasting station is a mystery to many, so a very interesting chapter on this topic opens the book.

Other chapters give details of the individual appliances of the art and of the buiding of standard sets. The references to inventors and developers is open to some criticism, on the ground of omission in at least one case, but the history of the subject is only an incidental feature of the work.

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## Experiments with Manganates and Permanganates

*(Continued from page 219)*

crystals in a small crucible or evaporating dish and cautiously add a few drops of concentrated sulphuric acid, we obtain a dark green, oily liquid, the constitution of which is expressed by the formula, $(MnO_3)_2SO_4$. If some water is present, a darker liquid, known as manganese heptoxide, is formed.

When making or handling the above liquid, care should be taken not to spill it on clothing or the hands. It is a very powerful oxidizing agent and a piece of paper dipped into it will burst into flame; in the same manner, illuminating gas can be ignited by passing it over the surface of the liquid. Allow a few drops of the liquid to fall on some dry sodium carbonate contained in a small evaporating dish. Violet fumes are formed of a substance supposed to be manganese trioxide.

Another rather spectacular experiment, which I believe was described in this magazine several years ago, consists in partly filling a test tube with alcohol and then adding several cubic centimeters of concentrated sulphuric acid in such a manner that it does not mix with the alcohol, but forms a layer beneath it. Now drop in several crystals of potassium permanganate and step back. Soon a sputtering noise is heard, and violent flashes of light are produced. This phenomenon is due to the reaction between the sulphuric acid and the potassium permanganate and the reaction of the resulting product with the alcohol.

Place a small amount of alcohol in a test tube and add a few drops of potassium permanganate solution. Boil until the color of the mixture has disappeared and then add a small quantity of sulphuric acid. Heat again for a few moments and then notice the odor of acetic acid. In this case, the potassium permanganate has oxidized the alcohol to acetic acid.

## Electroscope for Detecting Small Discharges

*(Continued from page 231)*

plane face of the hemisphere (D) rests upon the upper end of the tube. Invert the whole and fill the glass tube with molten sealing wax (H). When the insulation has cooled, the rod will be embedded in its center.

Some gold-foil, which can be purchased for a small sum from a glazier, is cut into strips one-quarter inch wide and two and one-quarter inches long. Try to have this cutting done by a professional, but if this is impossible it is best done by leaving it between the sheets of paper as it comes and cutting paper, foil, and all. The plate (A) should be smeared with albumen, thin shellac, or, better still, a solution made by dissolving a large capsule case in a tea spoon of warm ether, as an adhesive. Two strips of gold-foil (I) are then affixed to opposite sides of the plate, leaving two inches of the strips hanging free. Fixing and attaching the gold leaves is the most difficult operation in the whole process. The foil, of course, cannot be touched by the hand and must be handled exclusively by some improvised instrument such as a narrow strip of paper.

Few hints can be given as to the best way to proceed with the attachment, so the constructor must rely upon himself.

The flask (J) must be clean and dry. Before placing the cork containing the rod in place permanently, heat the flask for a few minutes at a moderate temperature so as to exclude all the moisture from the interior. While the flask is yet warm, place the cork in the top so that it is one-eighth inch below the mouth. Pour molten sealing-wax (K) on the cork until it is level with the top.

Give the neck of the flask several coats of shellac on the outside to prevent moisture approaching the insulation. If it is desirable to make condensing equipment for the electroscope, cut two disks, each two and one-half inches in diamenter, from one-sixteenth inch brass. By means of solder (L) affix a piece of three-eighths inch brass rod five-sixteenths inch long (M) to the center of one of the disks (N). Drill a one-eighth inch hole in the end of the rod to a depth of three-sixteenths inch and tap as was the case with the charging knob.

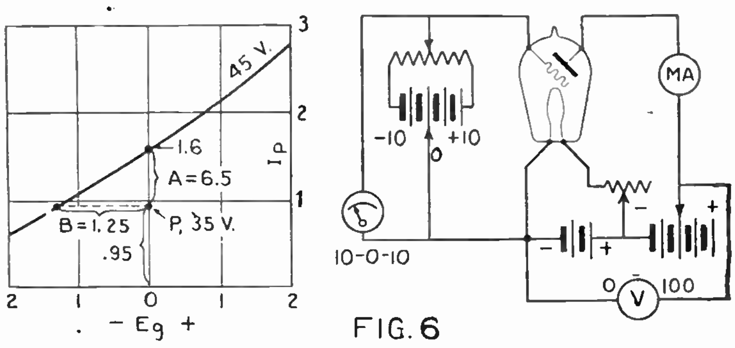
# The Evolution of the Vacuum Tube

(*Continued from page* 205)

becomes readily apparent that the amplification factor $\mu$ equals 10 volts (the plate voltage change), divided by 1.25 volts (the grid voltage change). The obvious result is the abstract number 8.

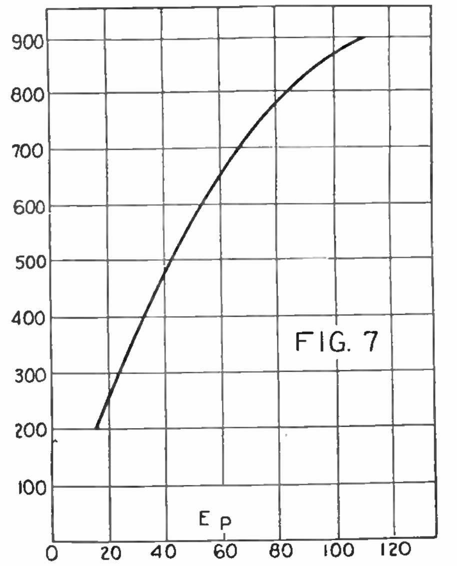
The amplification constant is a valuable index of the value of the tube as an amplifier and should be in the vicinity of the number given for the type —01A tubes. For the type -99 tube a value of 6 is good.

*Plate Resistance or Output Impedance.* We have seen that with a normal potential of 90 volts on the plate of the tube and with a normal filament potential, the amount of plate current was readily variable by changing the potential on the grid. In effect, the variation of plate current is thus due to the change of internal resistance of the tube. By definition, the plate resistance is simply the ratio of change in plate voltage to the change in plate current. As in Fig. 6, the change in plate voltage from 45 to 35 volts resulting in 10 volts was responsible for the change in plate current from 1.65 to .95 mils, or namely .00065 ampere. The ratio 10 to .00065, therefore, results in 15,400 ohms resistance (plate to filament resistance). Higher plate voltages will somewhat decrease the plate resistance, showing a slight deviation from Ohm's law.




**Circuit diagram with which the amplification constant, plate resistance and mutual conductance are obtained. The graph should be studied closely.**

*Mutual Conductance.* The mutual conductance of a tube is defined as the change in plate current divided by the change in grid voltage to produce it. In other words, the worthiness of a vacuum tube lies in the ability of the slightest grid potential to produce the greatest change in plate current. The value of mutual conductance changes, as can readily be seen, with the slope of the characteristic curve, for near the bend of the curve it is small, whereas on the straight or steep portion it is large. The accurate reading to be taken, therefore, is at the point at which the tube is to be operated. Thus in Fig. 6 we saw that 1.25 volts grid potential change caused a change of .65 mil. plate current, and the slope of the curve at that point is 0.52. Since we are using milliamperes instead of amperes, we must divide this value by 1,000; and further, because our expression must be in terms of micromhos instead of mhos, we must multiply by 1,000,000. Thus the figure 0.52 is multiplied by 1,000, which gives us the value of 520 micromhos as the value of mutual conductance of the tube. Fig. 7 and Fig. 8, respectively, show how the plate resistance and the mutual conductance vary with different plate voltages, at zero grid potential.




**Showing how the mutual conductance varies with the applied plate potential. As can be seen, it is approximately 800 micromhos at 90 volts.**

For our discussion of the characteristics of the vacuum tube, we have dealt with the small receiving tube. However, there are much larger tubes made for all kinds of power work, ranging in size from the small type —99 to the 250-kilowatt water-cooled transmitting tubes.

The power input (the filament consumption is not regarded) is measured by the product of the plate voltage and plate current, and the power output is calculated after subtracting the power dissipated in the plate, as heat, etc., and, usually, for a good tube, the output is approximately one-third the input. A 50-watt tube (output) thus requires 150 watts input for normal operation (1,000 volts plate voltage and 150 mils plate current).

In receiving, the grid potential on the detector tube (when not preceded by radio frequency amplification) may be exceedingly small; in fact, not measurable by any instrument or device other than the vacuum tube. For example, in a good 5-tube radio frequency set, in which the losses are low enough to obtain the best possible regeneration over the entire broadcast range of wavelengths, the total plate current as shown by the insertion of a milliammeter in series with the negative terminal of the "B" battery, may run as high as 25 mils. Careful examination of the needle pointer may reveal the astounding fact that the maximum deflection when music or speech is tuned in may be but two or possibly three milliamperes! Consider, then, the existing instantaneous maximum potential on the grid of the first tube! It is so inconceivably small that it is practically impossible to figure it. If it were but a matter of tube voltage amplification, it would not be difficult, but since regeneration enters into the problem, it becomes very complex. At any rate, it is only the variation in plate current which affects the diaphragm of the loud speaker, the steady plate current acting rather as a deterrent for fidelity of reproduction.

This article concludes the series and it is sincerely hoped that many points of interest have been clarified.

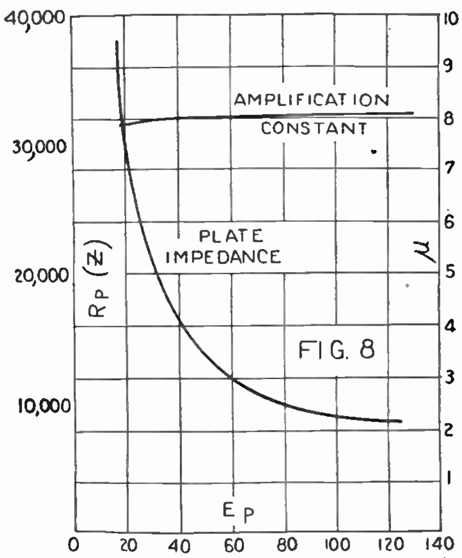



**Plate impedance also varies with the plat potential, as can be noted in the graph. Th amplification constant remains practically th same.**

# Improving the Antenna

(*Continued from page* 215)

of your receiver. Such an arrangement is at best, only temporary. A more permanent installation can be had by twisting two pieces of bell wire tightly together to form a length of twin conductor with a sufficient capacity between each conductor through the insulation to provide a very satisfactory condenser. Of course, the two wires are not directly connected electrically and care should be taken to see that the ends are properly staggered so there will be no danger of an electrical "short." The length of this twisted condenser, thickness of the insulation, size of the wire and tightness of the twist determines the capacity. The best feature of this arrangement is that the whole thing can be coiled loosely and hidden away or can be made a part of your ground wire.

Another hint—join the two wires of one end of this condenser together through a simple open-and-close switch, as it often happens that there is only one local broadcast station, which causes trouble, and this condenser need not be employed when this particular station is not broadcasting. In this event, close the switch for distance; when the local comes on, open the switch and the condenser is cut in for selectivity (Fig. 2). If these makeshifts prove thei value, but you are not satisfied with thei design, it is suggested that you purchase a small fixed condenser, the kind about ar inch square, with metal end pieces. Whe you have found the proper capacity require for your particular antenna, connect it perma nently in the antenna circuit. This type o condenser can easily be shorted out by snap ping a heavy metal jaw paper clip directl across the two metal end pieces to serve th same purpose as the switch mentioned abov (Fig. 3).

(*Continued on next page*)

# Electric Incubator or Bread Raiser

(Continued from page 232)

shelf of heavy screen or wood slats. An inch below this suspend a horizontal baffle consisting of a 7/8-inch board about 6 inches smaller than the shelf each way and centered to leave a 3-inch space all around for heat circulation.

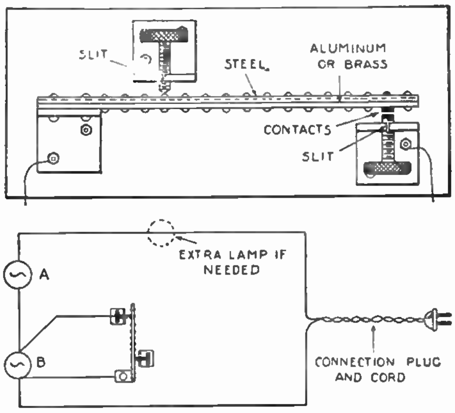
At some convenient place on the sidewalls, about midway between the shelf and the top, place the thermostat, described later. Another porcelain receptacle is mounted either beside the first or on the outside of the incubator, the location being determined by the heat losses of the incubator. It may be placed outside for summer operation and inside for winter use, or one may be provided at each place. In the event that both lamps are placed inside, care should be exercised in choosing sufficiently small lamps, so that the two operated in series may not overheat the incubator.

A tight-fitting door is provided for the incubator, which may be either side-opening or top-opening depending on the use to which the incubator will be put. Construct a glass peep-hole therein.

The writer mounted a thermometer against this opening so that the working portion of the scale was visible.

The thermostat is constructed as shown, in sketch, the parts being mounted on a bakelite base with good, stiff angles of brass, about 1 x 1 x 1/8-inch. In tapping for the adjusting screws, first drill the angle, then slit with a thin hacksaw, then tap. This will provide enough friction to hold any adjustments made.

The thermo-element may be made of a 1/32 x 1/2 x 6-inch strip of steel, and a similar strip of brass, or preferably a strip of




**The thermostat and the layout of the connection for an incubator. Thermostats can be purchased in the supply stores.**

cold-rolled aluminum about 1/16-inch thick. Clock spring or phonograph spring is suitable for the steel, and spring brass is better than soft. The strips should be riveted together along the center line, not less than 3/8-inch apart, using small brass rivets or drive screws. This element should be very solidly attached to its angle; in fact, looseness is undesirable at any point. It is best to rivet this joint.

On the free end of the element mount a contact rivet. Drill the end of the contact screw, and mount another contact rivet therein. Contacts in the form of rivets may be purchased, or very good points made of silver wire. Select a piece of steel as thick as the length of the rivet, and drill through it a hole slightly larger than the wire. Cut off a piece of wire a little longer than the finished rivet, and insert it in this hole, with the steel held on an anvil. Hammer out the surplus wire to form a head. Such rivets may be used for a variety of contact work.

The contact rivet in the thermo-element should be headed on the aluminum side, and the contact screw should be mounted in its angle on this side. The rough adjustment screw and its mounting angle are placed on the opposite side, about 1/2-inch away from the thermo-element mounting angle.

Wire up the receptacles and thermostat as shown. Note that the receptacles are wired in series and that the thermostat simply shunts one so that it is practically out of circuit. This prevents excessive sparking at the contacts. If any difficulty is found in obtaining a sufficiently low temperature, a third or even fourth lamp may be wired in series with the others and mounted outside the incubator.

To adjust, place a suitable thermometer inside, on the shelf. Adjust the screws just to make contact and extinguish one lamp. Close door and wait until other lamp, which is bright, burns dim, as seen through the peep-hole. Quickly open the door and read the thermometer. If the temperature is too low, adjust the screw closer; if too high, back the screw out. Readjust several times until the temperature is correct. Then note whether the lamp flashes often, and if so use a smaller size in socket "A" or a larger size in socket "B." A minimum of thermostat operation is desirable.

# Improving the Antenna

(Continued from preceding page)

### Shortening the Antenna

Oftentimes, these simple remedies will suffice and it will not be necessary to actually shorten your antenna greatly. So much the better, otherwise decrease your antenna length until results are obtained by chopping off five or ten feet at a time until an increase in selectivity is obtained, or until signal strength falls off greatly. This brings us to the discussion of the number of wires to be contained in the flat top and the unobstructed or clear space available in which you may erect your antenna. To compensate for the weak signals when the antenna is shortened, or when it is necessarily short because of limited space, add a few wires to the flat top, or by other means increase the effective area. However, care must be taken or else selectivity will again be as bad as before.

A very satisfactory manner in which to shorten the effective length of the flat top portion and in some cases decrease the directional effect, is to make a "T" antenna out of an inverted "L" type. The effective length of the flat top now is reduced approximately one-half. This places the lead-in at the center of the flat top—be sure it is in the exact center and not a third or a fourth from one end.

### The Inverted Pyramid

If the antenna you are using does not seem to meet your requirements, may I suggest for your consideration an inverted pyramid with the down-leads bunched and, incidentally, the down-lead or lead-in should always contain as many wires as the top portion. Such an antenna usually does not require an enormous space in which to be erected. An idea can readily be obtained of an inverted pyramid antenna by picturing an umbrella which, having been turned inside out in some wind storm, has also had its covering removed, revealing the bare ribs and stays. The metal handle rod illustrates the down-lead, while the ribs, extending radially upward from a common center, are the wires. These wires should be from ten to twenty feet long, equally spaced and pointing upward at an angle depending upon the selectivity desired.

Such a design has many possibilities and should give an ample opportunity for experiments. Once you have given it a trial, I am certain you will never go back to the conventional design you see on every roof. Briefly, the reason will be found in the following advantages: Non-directional (or semi-directional by lowering the horizontal plane of the wire pointing away from the direction of the station whose signal strength you wish to augment); unusual sensitivity; easily adapted to a limited space; less inductive pick-up, because its design prevents any paralleling of your neighbor's antenna or nearby high tension lines, and easily proportioned to meet the requirements of any receiver, be it the simplest crystal set or an elaborate super-het.

### General Constructional Details

Before we bring this article to a conclusion, let us briefly consider certain points in antenna design that may have previously escaped your notice. No matter how good the construction, nor with what detail your antenna has been erected, certain minor points can make or mar. For instance, your antenna should be as high as possible, even to the extent of the down-lead being two-thirds of the total over-all length. This insures sensitivity and selectivity and decreases any pronounced directional effort.

It is poor construction to extend the antenna to within two or three inches of the pole or other support to which it is tied. Why not keep it in the clear by leaving at least three feet dead-end between the last insulator and the supporting object? And it is advisable to have the supporting wires and ropes of sufficient strength to care for an ice load during sleet storms and wind storms; it must be weather enduring.

The insulators, too, should be of good tensile strength, and preferably of glass or glazed porcelain. And it might be a very good idea to institute a periodic cleaning program. This especially applies in cities like Chicago or Pittsburgh. Seriously, some broadcast stations in this city clean their glass as often as every month, proving that yours might well be polished at least semi-annually.

The wire question is easy to agree upon. Use none smaller than size No. 14 B. & S. copper out-of-doors. If you live in the wide open spaces, the wire will probably not become covered with soot, hence bare wire is as good as any. In cities, it is always preferable to use enameled wire. When erecting the antenna, make splices only when necessary, and then assure perfect connections by soldering, or by use of copper sleeves.

Keep the entire antenna, including down-lead, free from all portions of the building—the greater the separation, the less loss, and certainly the sharper tuning.

Acute angles in antennae are bad form. If angles are necessary, see that they are obtuse.

There are many additional points which could be mentioned, but you have no doubt heard of them before. If not, your better judgment should guide you; for, after all, the construction of a satisfactory antenna is not so difficult. It is more the purpose of this article to get your attention away from your receiver for a few moments, in order that any faults not inherent in your receiver may be traced to their proper source and corrected. Your antenna is your outward expression to the world that you are a radio fan. Do not neglect your antenna.

motions may be adjusted for different velocities. A wave started in the vertical plane maintains itself vertically and a wave started horizontally maintains itself horizontally. If, however, a wave is started in a plane 45 degrees between the vertical and the horizontal, it is found that the wave motion proceeding therefrom assumes the shape of a corkscrew. The straight-line oscillation

(*Continued on page 253*)

## Fire Under Water

(Continued from page 217)

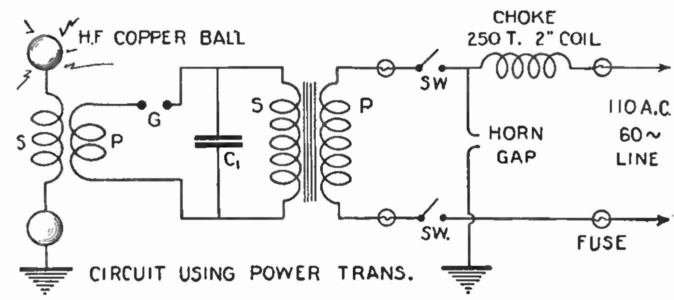
Everything in the chemical laboratory wants to be done rightly. The idea that people take meticulous care in ordinary things, is often made a subject for criticism.





# A Practical Tesla Coil

(Continued from page 229)




The first of two suggested circuits to supply power to the coil. In this one a power transformer of simple description is used and the conventional lettering can be followed by the reader. Note the choke coil and horn gap, and condenser.

determine which carry low frequency current from the high frequency lines and be very cautious when handling these as they may give a very severe shock.

Many wonderful experiments may be performed with this coil with the Geissler tube and wonderful glows in a dark room will result. An ordinary incandescent globe will produce a beautiful lavender glow.

A wire may be connected to the high potential end of the coil and a great brush discharge will take place, making a dull glow and crackling sound. The wire should be cut and lengthened until the proper length is found, at which the greatest discharge will occur and produce the most brilliant glow.

The insulating qualities of this coil if they are good will help prevent excess brush discharges and only in this way can the fullest results be obtained. To test the insulating qualities of slate, marble, bakelite, celeron is a very interesting process and one will be surprised at the results. Many preconceived "notions" will be "blasted" after these tests are made.

Another interesting experiment is to make a long wire spinner, place it on a needle-bearing at the tip of the coil and watch it revolve at a high rate of speed depending on the frequency of the current. This gives a good photograph.

The same result showing whether one is getting complete "CW" from his transmitter is to place the Tesla secondary inside the "CW" inductance and apply the power supply. This is a "modulatoscope." Accurate results will require photographing the discharge. With these conclusions one may place the necessary chokes and filters in his plate supply line to produce the best wave.

The breakdown qualities of a condenser of mica, glass or other dielectric can be readily found out by connecting it to the high potential. Perhaps the most peculiar experiment is to test the insulation of a so-called safety screw-driver used by electricians. Note the results.

The discharges may be taken by the person performing these experiments employing a metallic rod to draw them off. This is not a painful practice. In fact, the actual discharge on to one's finger tips is rather exhilarating. These high frequency currents travel on the outside of the body and cause no apparent harm. This cannot be said of the low frequency curreent. Play safe!

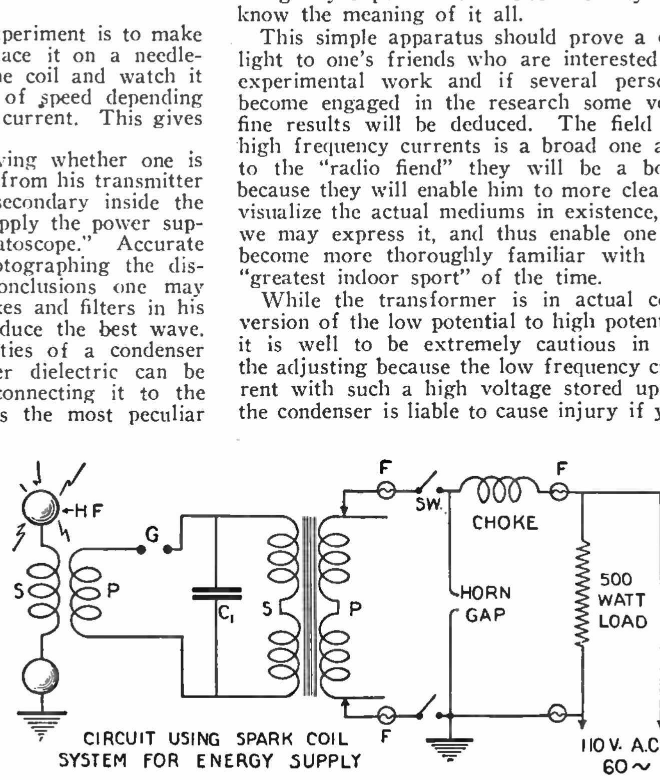
The antenna for radio purposes may readily be tested for insulation leakage by applying the high potential and searching for it with a neon gas spark plug tester which glows when a high frequency current passes through it.

Do all antenna testing at a time of the day when the radio listeners are not receiving the broadcasts or else you'll "QRM" the whole neighborhood. This need hardly be said to a real true experimenter, but it is a precaution. Conduct all these experiments as quickly as possible if in the evening, because the discharges will interfere with radio reception.

With this Tesla transformer one may conduct an endless number of experiments which are too numerous to mention here and it will be well to look up some information on high frequency currents before actually doing any experiments or else one may not know the meaning of it all.

This simple apparatus should prove a delight to one's friends who are interested in experimental work and if several persons become engaged in the research some very fine results will be deduced. The field of high frequency currents is a broad one and to the "radio fiend" they will be a boon because they will enable him to more clearly visualize the actual mediums in existence, as we may express it, and thus enable one to become more thoroughly familiar with the "greatest indoor sport" of the time.

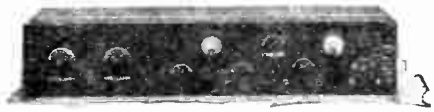
While the transformer is in actual conversion of the low potential to high potential it is well to be extremely cautious in all the adjusting because the low frequency current with such a high voltage stored up in the condenser is liable to cause injury if you happen to receive an electrical shock. Constant caution will well repay and is to be preferred to saying it with flowers.




This connection is similar to the one above but a spark coil system is used for the supply. Again we find a horn gap, choke coil and condenser. In both these connections the condenser is in parallel with the coil.

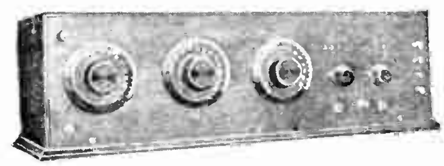
# Just Seven Simple Tools


SUPER-HETERODYNE



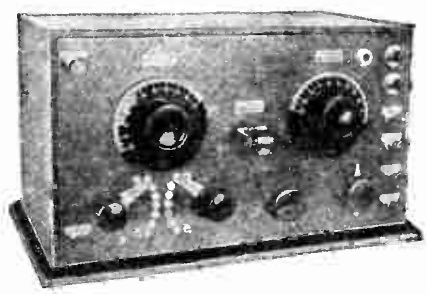
THE TROPADYNE

THE NEUTRODYNE

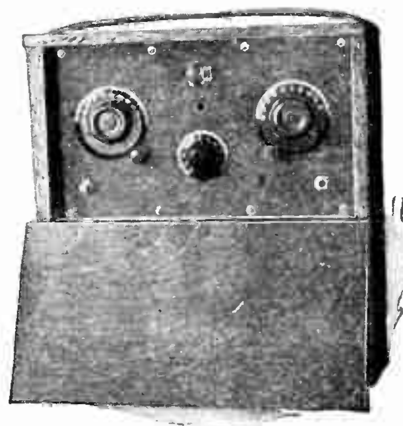


5-TUBE COCKADAY

THE REFLEX



THE PORTABLE



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# EXPERIMENTER'S PATENT SERVICE

EDITED BY JOSEPH H. KRAUS

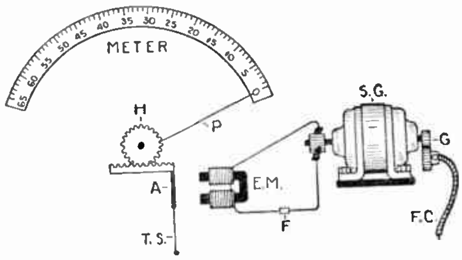
ON this page every month we will give our readers the benefit of our experience on patents and questions pertaining to patent law. Years of our treatment of the subject of patented, patentable (and many unpatentable) devices has proved satisfactory to hundreds of thousands of experimenters. The writer, 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.

## Electric Speedometer

(29) R. Whiteman, Montvale, N. J., sends a sketch of an electric speedometer and writes: The flexible chain operates a small generator, which in turn sends a current of electricity through the electromagnet. The magnet draws its armature to it, turning the cog wheel (H). To the shaft of the cog wheel is fastened a pointer (P). Therefore the faster the automobile travels, the stronger the current is, which in turn strengthens the electromagnet and the pointer (P) moves further to the left.

If the speedometer registers up to 65 miles an hour, the wire which carries the current to the electromagnet should be large enough to carry it without melting. Then if a car goes 75, which is more than the speedometer can register, and the wire leading to the magnet might melt, to protect the wire I have used a fuse (F) which is to blow before the wire.

Please give me your opinion of this speedometer.




**Suggested arrangement of parts for an electric speedometer to be used upon an automobile, relying for its action upon the change in potential and consequently in current produced by a small generator, which charges an electromagnet.**

A. We would not suggest that you apply for a patent on an electric speedometer because of the fact that the device is complicated, too expensive to manufacture and will probably be inaccurate. The prime reason for the inaccuracy lies in the fact that the generator will not give a constant potential at a constant speed, because a little oil on the brushes or comutator will change the reading. Differences in tension of your springs, unless carefully regulated, would make the armature inaccurate. This device would have to be built like a very accurate voltmeter and would not stand rough usage.

The whole affair seems too heavy and complicated and it is questionable whether the extra weight and complication will be compensated for by any advantages over the simpler type of speedometer now in use on automobiles. When one is on the road, a sort of general rule is that the simpler things are the better. One of the troubles with the modern automobile industry is a tendency to complication which is brought about largely by the idea of novelty. The eight-cylinder engine with inclined cylinders and all sorts of refinements for preserving an even temperature and the like involves such features and even now we see a tendency to get away from this engine by using a straight-line engine with its eight cylinders also. So it would seem that you, in introducing a dynamo which would have to have its brushes renewed, and the mere renewal of which brushes would probably change its rating, which would require oiling or attention to grease cups and which inevitably will weigh something, and would seem to be a poor substitute for the present very light and almost fool-proof speedometer.

## Static Eliminator

(30) Mr. H. T. Yopp, of Bradenton, Fla., states that he has an idea for a static eliminator which consists of a set of tuned strings or tuning forks of different pitches, which are mounted in front of a loud speaker and the whole is then fixed in a sound-proof box. Incoming radio music causes the springs to vibrate, making electrical contacts, and the electrical vibrations thus produced are to act upon the loud speaker placed in the room. Static being a noise, rather than a sound, and having no definite frequency, will not actuate the tuned strings. Consequently, the set will not reproduce the cracking sounds incident to thunder storms. He requests our opinion on this static eliminator.

Concerning your static eliminator, we would advise that we do not think this idea is practical. Again going over your theory, we find that you have a series of magnets operating a set of tuned strings corresponding to all the musical notes. Static not being a musical sound, but, rather, a noise, should, therefore, not filter through this particular circuit. You are to amplify the sounds produced by the vibrating strings or you may substitute tuning forks for the strings.

Assume now that a piano solo is coming across the air. It is quite evident that if everything could be made to operate properly the strings or tuning forks would vibrate. But you must remember that those strings or forks will vibrate at their own frequency and *with their own characteristic.* This means that a tuning fork producing a pure wave will always produce that pure wave regardless of the nature of the instrument transmitting at the broadcast station and a violin would sound nothing like a violin at all. Then the announcer would announce the next number, and you can clearly see that it would be impossible for you to duplicate the announcer's voice or really reproduce the human voice in any manner.

## Fire Under Water

(*Continued from page 217*)

Everything in the chemical laboratory wants to be done rightly. The idea that people take meticulous care in ordinary things, is often made a subject for criticism. But in the laboratory where one is working with strong chemicals, care and manipulation should be absolutely meticulous. When you remove the thistle tube from the flask, it should at once be held over a beaker or put into a cylinder so that the acid will not drain down and drop from it upon anything. Phosphorus looks like a very innocent substance; but it will burn you very badly, and it is a cumulative poison in the yellow modification. If cut in the open air, it will probably catch fire. If sulphuric acid is poured upon potassium chlorate not covered by a layer of water, the reaction will be almost explosive.

While the writer, who has often shown this experiment, never had any trouble with it, there is always the possibility that the flask may break, so it should be supported above an evaporating dish or a photographic developing tray, or the like. You are dealing with what may be termed the most critical kind of chemicals and with one or two very violent reactions, that of concentrated sulphuric acid upon potassium chlorate, and of chloric acid upon phosphorus. There may be some spray thrown out from the flask, so keep your face away from it.

Accidents occasionally happen in chemical laboratories, but they are rare. Practically all of them are avoidable.

## Interesting Properties of Hydrogen,

(*Continued from page 222*)

vibration of the air particles which are set in motion by the burning hydrogen.

A very novel experiment, which illustrates the weight of hydrogen relative to that of air, as well as its combustibility, can be performed by means of the apparatus shown in Fig. 10. Connect the clay pipe with the

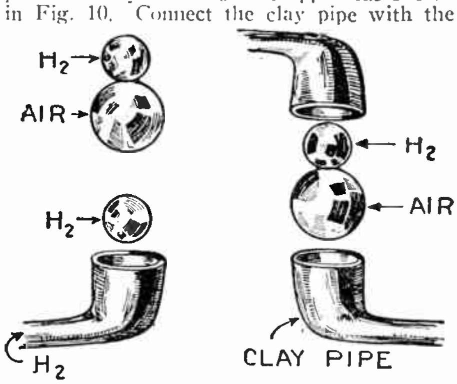



FIG. 10

**Experiments with soap bubbles, some blown with air and some blown with hydrogen, illustrating the lightness of the gas in question.**

hydrogen generator and regulate the flow of the gas so that the pressure will not be too great. Make some soapsuds and add a little glycerine, so the mixture becomes tough and the bubbles will not burst readily. Dip the pipe into the suds and allow the gas to fill the bubbles gradually. You will be surprised how quickly the bubbles will rise like little balloons. If a lighted taper is quickly brought in contact with them, a very loud explosion will result, showing that hydrogen forms an explosive mixture with air. If you now take another clay pipe and make ordinary soap bubbles filled with air and bring them in contact with hydrogen-filled bubbles, the hydrogen bubbles will easily carry them along upward into the air.

## The Cathode Ray Oscillograph

(*Continued from page* 225)

tained at a frequency of about 500 with ultra-sensitive plates.

The above experiments by no means exhaust all possibilities for the oscillograph. A vast field is still open for investigation, for instance, to show some of the latest experiments we find in Fig. 15 the characteristics of an amplifying or sender tube, the curve representing anode-current versus grid-tension for 135, 714, 1175 volts.

The way to proceed is: Alternating tension from grid to amplifying tube on one side and on the other to the condenser of the oscillograph; the resulting anode-current in its turn was sent through the coils. Fig. 16 is a hysterisis loop of a closed transformer with laminated core. Anyone who knows how difficult it is to obtain such diagrams by static means, will appreciate the great facility offered by the oscillograph and although the result may not be absolutely the same, for practical purposes it is quite reliable.

## Polarization of Radio Wave

(*Continued from page* 209)

will be adopted will depend upon further results from the comparative tests that are now in progress, and also upon final tests in the stations when installed. So far, these tests have shown that the horizontally polarized radiation is superior to vertical radiation.

### Mechanical Model for Studying Wave Polarization

I have a mechanical model, made up for studying wave polarization, in the General Electric laboratory. The model consists of weights suspended in such a way that they are free to move in all directions. Twenty-two of these weights are arranged in a row and connected together by rubber bands. Each weight is suspended from a yoke and an equal weight hung on the other side of the yoke to serve as a counter-weight. This model was set up especially to study the twisting of the plane of polarization and the experiment has strikingly confirmed the theory which it was intended to illustrate. This theory is, briefly, the following:

We will assume that the medium through which the radio waves pass, has such characteristics that the velocity of propagation for a vertically polarized wave differs slightly from the velocity of the propagation for a horizontally polarized wave. It is not necessary for the present purpose to try to explain the reason for this difference in velocity. We may assume that the reason for it is due to the electrostatic and magnetic effects, to the retarding effect of the velocity of the vertically polarized wave passing close to the earth, or, on the other hand, due to properties of free electrons in the upper atmosphere. Whatever the cause may be, we may assume that such a difference of velocity exists and the mechanical model has been constructed so as to reproduce such conditions.

The weights on both sides are tied together with rubber bands. Wave motion in the horizontal or vertical planes can thus be studied independently, and these two wave motions may be adjusted for different velocities. A wave started in the vertical plane maintains itself vertically and a wave started horizontally maintains itself horizontally. If, however, a wave is started in a plane 45 degrees between the vertical and the horizontal, it is found that the wave motion proceeding therefrom assumes the shape of a corkscrew. The straight-line oscillation

(*Continued on page* 253)

## The Electron

(*Continued from page* 207)

I have left until now the most important method of obtaining electrons, and that is—by the heating of metals. Let me repeat that our present theory regarding metals is that they are made up of atoms, which can quite readily lose an electron and that, therefore, we have present in any piece of metal a large number of electrons which are free—or nearly free—from their atoms, and that it is for this reason they are good conductors of electricity. The results of experiment are such that the present theory goes further and says that these electrons are in violent motion in all directions in a completely disorganized manner so that if we could see them, they might look something like a swarm of bees in a woods. Because of their high velocities, it might be expected that they would shoot right out of the metal, but there is a force opposing this and only those with high enough velocity can overcome this force. At ordinary temperatures the number which have this necessary velocity is negligibly small; but as the temperature is raised, the velocity of the electrons is increased and the number which can get out also increases.

The easiest way to heat the metal is to have it in the form of a wire and send an electric current through it. If now we put a metal plate near the wire and connect the negative end of a battery to the wire and the positive end to the plate, the electrons will be attracted by the positive charge on the plate and will flow from the wire to it across the intervening space and so constitute an electric current. It is preferable to have the wire and plate enclosed in a highly evacuated vessel in order to avoid collisions with gas molecules. This effect was first discovered by Edison.

DeForest found that if, between the wire and the plate, he put a metal screen or grid, he could control the current to the plate—*i. e.,* the number of electrons coming from the filament. If it were charged positively the current increased, and if it were charged negatively, it decreased. Not only this but he found it would respond to the high frequency waves which we call "radio" and most of you who are listening-in have such a device as a detector of the radio message. Some years after his first discovery, DeForest found that this vacuum tube device would act as an amplifier of weak electric impulses, such as telephone currents, and as a result of improvements made in its structure, many of you this evening are using vacuum tubes for amplifying the radio signals after these have been detected by a tube of the same form, operating in a somewhat different manner.

It is scarcely necessary for me to recite the other common uses of this device, how it is used as a generator of the high frequency oscillations or waves, how it is used for impressing the voice on these high-frequency oscillations, how it is being used for relaying the long distance telephone currents all over the length and breadth of the land, or how it is being used in any place where one wishes to amplify electric impulses. The vacuum tube in the form just described is permitting us to enter into fields which we had never hoped to enter before, and has opened up such vast possibilities for research and investigation that I believe it a true statement to say that it is the most important tool placed in the hands of science in the last three decades. And it all involves and depends on the discovery and the study of the electron.

Let me call your attention to another use of electrons. In 1895 the world was astonished by a report that a new kind of ray had been discovered by which it was possible to take photographs through opaque bodies or to see through them. Now-a-days we are so familiar with X-rays that they no longer excite much curiosity, but since they are due to electrons, I would discuss them very briefly.

The first form of X-ray tube consisted of an evacuated tube with a positive and a negative electrode. While the evacuation was high, there was a sufficient amount of gas left to give a number of electrons, but so few that most of the electrons formed traveled directly across to the positive plate or target without collision with gas particles. If the voltage between the electrodes was quite high, say twenty or thirty thousand volts, the electrons would strike the target with enormous velocity and would be very suddenly stopped. This sudden stoppage of the electrons sets up what we now recognize as disturbance in the ether similar in every respect to light waves except that they are very much shorter and because of this, have the power of penetrating many bodies opaque to ordinary light.

Such an X-ray tube has the disadvantage of being quite irregular in its behavior because of the gas present and a great improvement was introduced a few years ago by Dr. Coolidge of the General Electric Company. In this tube, the source of electrons, instead of being the gas, is a tungsten wire heated sufficiently to give off electrons just as I described in connection with your detecting and amplifying tubes. These electrons are then shot across to the target as before and the results obtained are so superior that the Coolidge X-ray tube has now practically replaced all others.

I have told you of some of the outstanding direct applications of electrons. Space only prevents the mention of others, but enough have been given to show the part they are already playing in our affairs of the day. We may say here, as in so many other cases, that the credit for the fundamental discoveries which lie back of or which precede the applications must very largely go to the pure scientist who is controlled by his feelings of curiosity as to the nature of things, who is interested more in his search for truth than for any other results. And after all, may it not be that his greatest contribution is that which he makes to knowledge itself for its own sake? He thus helps to lead mankind into a fuller understanding of the universe in which he lives and has his being, a richer outlook on the spiritual aspects of life.

## Interesting Articles to Appear in February RADIO NEWS

New Developments In Radio Receivers, ................By A. K. Laing

This is one of a series of articles running each month in RADIO NEWS, the reading of which will acquaint one with the newest and best in radio.

The Autoregenerator, By Sylvan Harris

A new set in which regeneration is employed both in the R.F. stages and in the detector. Automatic control of the regeneration is provided, so that operation is maintained close to the critical point without any whistling or squealing.

The Duo-Wave Receiver, By Joseph Bernsley

This is a well designed receiver having two ranges, one range covering the broadcast band, and the other going up to 15,000 meters.

Where Radio and Heat Waves Meet, By Donald H. Menzel

Some recent researches in ultra-short waves are described. The waves are so short that they lap over into the wave range of the heat waves.

# "BUILD YOUR OWN" WITH "RASCO" PARTS!

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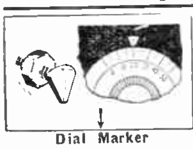
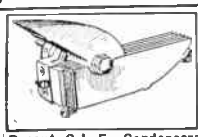


**Dial Marker**

The big little thing you have been waiting for. Just drill a hole in the panel and mount the marker above the dial. Nickel plated and polished

F7788 Dial Marker, three for ............$.10

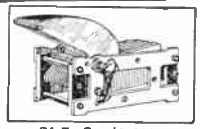


**Pacent S.L.F. Condensers**

The famous Pacent SLF Condenser. The latest word in condensers. Sturdy, compact, take up less room than most others. Minimum insulation used.

F4432 .00035 mf. 17-plate ............$2.95

F4433 .0005 mf. 23-plate ........... 3.95



**SLF Condensers**

Lowest prices ever offered. Despite this low price, these condensers are made with precision aluminum stampings, hard rubber insulation. Money back if not satisfactory.

F3513 .00025 13 pl..$1.06

F3517 .00035 17 pl.. 1.20

F3523 .0005 23 pl.. 1.35

**"Guaranteed" Vacuum Tubes**

We consider the "Guaranteed" tube one of the best on the market. Any tube replaced if defective, providing filament lights. Calibrated curve goes with each tube.

F701A 5 v. .25 amp.$1.25

F799 3 volt .06 amp. 1.25

**Audio Transformer**

This is the famous Pacent Audioformer. Nickel case is grounded to base. Extra high degree of amplification. Minimum distortion and reaction. Binding posts and solder lugs. Ratio 3½ to 1.

F2811 Mounted type $4.50

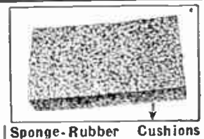
F2812 Unmounted .. 3.15

**Audio Frequency Transformer**

No better Transformer made. Highest class materials. Impregnated coils. Silicon steel stampings used. Save 50 per cent by assembling it yourself.

F1100 Ratio 4½-1..$1.40

F1150 Ratio 6½-1.. 1.40

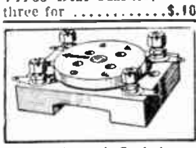


**Sponge-Rubber Cushions**

Get rid of tube noises due to vibration. Softest sponge rubber made. Size 2½"x3", ⅜" thick.

F8989 Sponge-rubber cushions, each .....$0.12

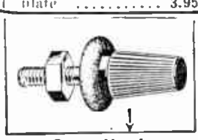
Six for ........... 0.60



**Universal Socket**

Takes new "X" type tubes as well as old standard "UV" and "C" types. Made entirely of Isolantite. No capacity effect between plate and grid. New phosphor bronze wiping contacts. Standard mounting type.

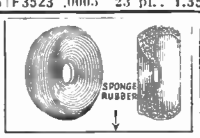
F6514 .............$0.49



**Rasco Vernier**

Why use a vernier dial when a vernier attachment will do anything and everything a vernier dial accomplishes? Cleverest vernier made. Can be used with any dial. Soft rubber ring engages dial. Nothing to come apart.

F1450 Vernier......$0.12



**FONEKUSHIONS**

Made of sponge rubber. Make wearing your receivers a pleasure. Positively exclude all noises and make reception a pleasure. Sponge rubber will last for years. Light as a feather. Sanitary.

F3550 Fonekushions, set of two ..............$0.35

**Dial Button**

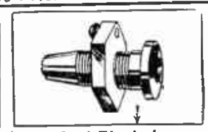
Made in blue enamel and gold, to be worn in button hole. Every radio fan wants one. ¾" diameter, best gold plate. Perfect reproduction of radio dial.

F7799 Dial Button, each ..............$0.25

**Vacuum Tube Shell**

Nickel plated shell for the man who builds his own. 4 holes to attach to subbase. Each shell comes complete with 4 phosphor bronze socket contacts. See illus. 4748.

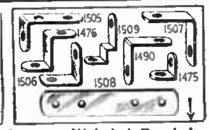
F4747 Vacuum Tube Shell and Contacts ......$0.16



**Cord Tip Jack**

Takes place of binding posts. Cord tip firmly gripped by jack. Made of brass, nickel plated. Screw to attach lead wire. No soldering necessary.

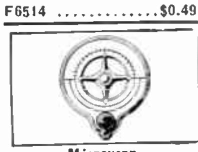
F1500 Cord tip jack, Each .................$0.15



**Brass Nickeled Brackets**

All Illustrations ¼ size.

| | | |
|---|---|---|
| F1505 | Bracket, each | $.05 |
| F1507 | Bracket, each | .05 |
| F1509 | Bracket, each | .04 |
| F1476 | Bracket, each | .05 |
| F1506 | Bracket, each | .05 |
| F1490 | Bracket, each | .04 |
| F1475 | Bracket, each | .03 |
| F1508 | Bracket, each | .05 |



**Microvern**

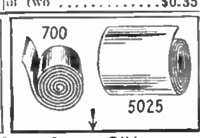
THE vernier dial for extra sharp tuning. No backlash. Special finish permits logging of stations on dial. Beautiful appearance. Comes in gold or silver finish. State which wanted.

F3066 Microvern, any finish ...........$1.76

**Rasco 180° Variocoupler**

Silk wire wound on bakelite tubes. Six taps. Wave length, 150 to 600 meters. For panel mounting. ¼" shaft. Your money refunded if it is not all we claim.

F3100 Variocoupler prepaid ..............$1.05



**Copper Ribbon**

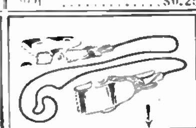
.0005" thick. F700 ⅜" wide; F701 ¼" wide; F702 3-16" wide. All sizes per foot...$0.01

**Copper Foil**

.001" thick. 4" wide.

F5025 Copper Foil, per foot ................$0.10

10-foot length ..... 0.80

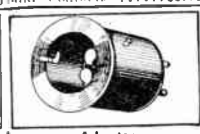


**Rasco Clip Leads**

Invaluable for experimental work. Clip lead hooks in a jiffy onto any wire, binding post or conductor. Safest experimental connection. Brass clips, 1 foot silk wire, green or red.

F7887 Clip Leads, ea.$0.12

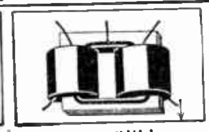
Dozen lot ............1.35



**Adapter**

Pacent Improved Adapter. Takes 199-type tubes. Fits standard 201A sockets. Phosphor bronze springs, short circuits impossible. Bakelite molded.

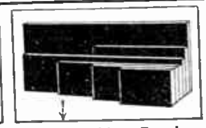
F652! Adapter .....$0.36



**PUSH-PULL**

Push Pull Transformer for many new circuits. See any radio magazine. Made of best materials. Silicon steel laminations. Coils impregnated. Save 50 per cent by assembling yourself. Simple instructions furnished.

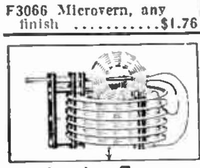
F1159 Push-Pull Transformer, ratio 6¼ to 1 $2.95



**Hard Rubber Panels**

Highest dielectric strength as per Bureau of Standards. Beautiful high finish.

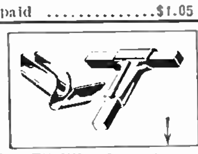
| | | |
|---|---|---|
| F7100 | 7x10x3-16" | .$0.65 |
| F7120 | 7x12x3-16" | . 0.79 |
| F7140 | 7x14x3-16" | . 0.89 |
| F7180 | 7x18x3-16" | ..1.15 |
| F7210 | 7x21x3-16" | ..1.31 |
| F7240 | 7x24x3-16" | ..1.46 |



**Low Loss Tuner**

Same type as used in our LOLOS EXPLORER. Tunes from 200 to 600 meters. Hard rubber insulation throughout. Silver plated primary. Secondary D. C. C. Tickler silk insulated wire.

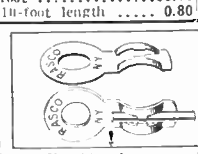
F2690 Tuner .......$5.00



**"T" Wire Connectors**

This big little article solves all troubles when making "T" wire connections. Made to take 1-16" square or round bus-bar wire. Can be attached with a pair of pliers.

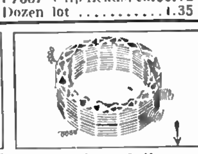
F2975 "T" Wire Connectors, 12 for.....$0.10



**Nosolder Lugs**

Finally, a real solderless lug is here. Soldering positively done away with. Takes square or round bus bar, which it holds with a vise-like grip. Perfect connection. Just slide bus bar into slip-grip.

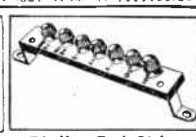
F3727 Lug, 25 for $0.20



**Low Loss Coil**

Same type as used in Freshman and other Tuned Radio Frequency sets. D.C.C. wire. 200-550 wave-length. 3" diameter. 1" wide. 5-16" thick 4 connections, 2 primary, 2 secondary.

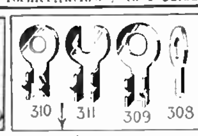
F2629 Low Loss Coil $0.43



**Binding Post Strip**

Made of hard rubber, gold engraved lettering. Two nickel brackets for mounting. 7 hard rubber binding posts. "ANT"; "GND"; "A—"; "A+"; "B—"; "DET B+"; "AMP B+".

F870 Binding Posts $0.35



**Tinned Nickel Lugs**

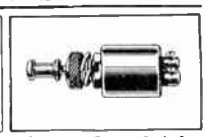
All our lugs are tinned.

F310 Brass Lugs for No. 8 screw, doz.......$0.10

F311 Copper Lugs for Nos. 6 and 8 screws, doz.0.10

F309 Copper Lugs for Nos. 1, 6 and 8 screws, doz.0.10

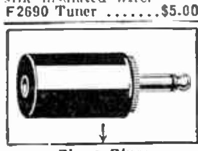
F308 Copper Lugs for 6-32 screw, doz. .........0.10



**Battery Snap Switch**

This Switch is produced under high standards of workmanship. Action is positive. Solderless contact screws used. One-hole mounting. Nickel-plated all over. Most serviceable switch made.

F7986 ............$0.36



**Phone Plugs**

Sold from 50c to 65c everywhere. Hard rubber composition shell and patented cord tip holder. Finest workmanship throughout.

F1030 Rasco Telephone Plug. Each .......$0.23

**Bakelite Socket**

Octagon shape. Four nickel binding posts, phosphor bronze contact springs. Best brown bakelite.

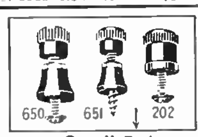
F6510 Bakelite socket $0.40

F6500 Tube Socket. Made entirely of composition. Best made. Each..$0.35

**Binding Post Name Plates**

Dia. ¾". These styles: Phones, Ground, —, Output, "A" Bat. —, "B" Bat. —, Loud Speaker, "C" Bat. —, Aerial, +, Input, "A" Bat. +, "B" Bat. +, Loop, "C" Bat. +, New! "A" Bat. + "B" Bat. —.

F6000 Name Plates, Dozen ............$0.15



**"Rasco" Posts**

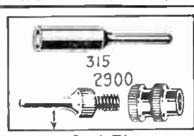
Made of hard rubber composition.

F650-51 Each .....$0.06

F202 Has nickel plated bottom, each .......$0.06

Dozen, each style...$0.70

F122 Initialed Binding Posts. Set of 8. Per Set ..............$0.25



**Cord Tips**

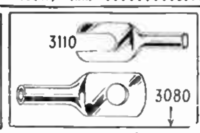
Standard phone cord tips, nickeled.

F315 Each .........$0.03

**Separable Cord Tips**

No solder required. Wire goes in ferrule. Shank holds it tight. Nickel plated.

F2900 Each........$0.06

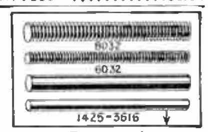


**"Perfect" Lugs**

These new and improved lugs are brass, nickel plated, flattened on top as shown. Made of a single piece of metal. Lead wire goes into tube.

F3110, F3080 "Perfect" Lugs. Each .........$0.02

Dozen lots ........ 0.20



**Brass Rods**

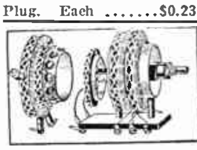
Sold in 6 lengths only.

F8032 Rod 8-32" thread length ............$0.08

F6032 Rod, 6-32" thread length .............$0.06

F1425 Rod, plain, ¼" round, length ......$0.10

F3616 Rod, plain 3-16" round, length .....$0.06



**Roberts Coils**

Diamond weave coils, used in standard Roberts Circuit. Tunes 200 to 570 meters. Used in 2, 3, or 4 tube circuits. These are genuine Sickles Coils, not imitations. Set comprises two units, as illustrated.

F-8112, Roberts Coils ..............$5.95

**100-Ampere Storage Batteries**

Guaranteed for two years. Only new material used. Genuine hard rubber case. Acid-proof terminals. Hard rubber vents. Strong carrying handle. Written guarantee goes with each.

F-9100, 6-volt 100-ampere hour battery ...$9.50

Shipped express collect.

## New 1926 "Rasco" Catalog No. 15

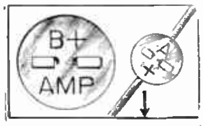
**CONTAINS 75 VACUUM TUBE HOOK-UPS, 300 ILLUSTRATIONS, 500 ARTICLES**

All Armstrong Circuits are explained clearly, all values having been given, leaving out nothing that could puzzle you.

Just to name a few of the circuits: The V.T. as a detector and one-step amplifier; all Armstrong circuits; one-step radio frequency amplifier and detector; three stage audio frequency amplifier; short wave regenerative circuits; 4-stage radio frequency amplifiers; radio and audio frequency amplifier; inductively coupled amplifier; all Reflex Circuits.

**FREE**

**A POSTAL CARD BRINGS IT**

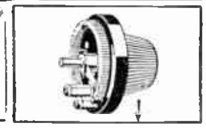


**NEW**

**Battery Lead Tags**

Latest wrinkle, made in metal, nickel-plated, polished. Clamp tag on battery wire, and it won't come off. These five styles: "B +", "B +. Det.", "B —", "A +", and "A —".

F8030 Tags, set of 10$0.15



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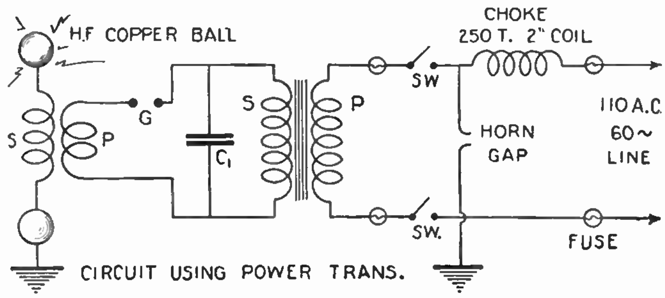
# A Practical Tesla Coil

*(Continued from page 229)*




The first of two suggested circuits to supply power to the coil. In this one a power transformer of simple description is used and the conventional lettering can be followed by the reader. Note the choke coil and horn gap, and condenser.

determine which carry low frequency current from the high frequency lines and be very cautious when handling these as they may give a very severe shock.

Many wonderful experiments may be performed with this coil with the Geissler tube and wonderful glows in a dark room will result. An ordinary incandescent globe will produce a beautiful lavender glow.

A wire may be connected to the high potential end of the coil and a great brush discharge will take place, making a dull glow and crackling sound. The wire should be cut and lengthened until the proper length is found, at which the greatest discharge will occur and produce the most brilliant glow.

The insulating qualities of this coil if they are good will help prevent excess brush discharges and only in this way can the fullest results be obtained. To test the insulating qualities of slate, marble, bakelite, celeron is a very interesting process and one will be surprised at the results. Many preconceived "notions" will be "blasted" after these tests are made.

Another interesting experiment is to make a long wire spinner, place it on a needle-bearing at the tip of the coil and watch it revolve at a high rate of speed depending on the frequency of the current. This gives a good photograph.

The same result showing whether one is getting complete "CW" from his transmitter is to place the Tesla secondary inside the "CW" inductance and apply the power supply. This is a "modulatoscope." Accurate results will require photographing the discharge. With these conclusions one may place the necessary chokes and filters in his plate supply line to produce the best wave.

The breakdown qualities of a condenser of mica, glass or other dielectric can be readily found out by connecting it to the high potential. Perhaps the most peculiar

travel on the outside of the body and cause no apparent harm. This cannot be said of the low frequency curreent. Play safe!

The antenna for radio purposes may readily be tested for insulation leakage by applying the high potential and searching for it with a neon gas spark plug tester which glows when a high frequency current passes through it.

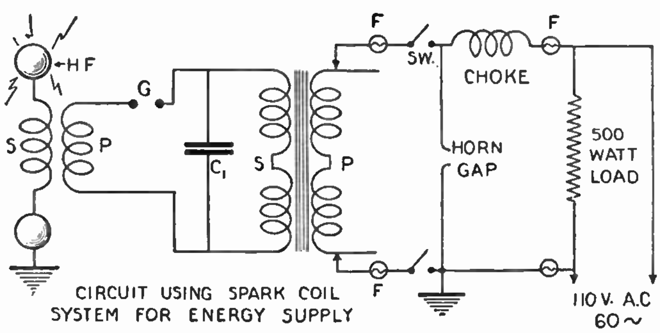
Do all antenna testing at a time of the day when the radio listeners are not receiving the broadcasts or else you'll "QRM" the whole neighborhood. This need hardly be said to a real true experimenter, but it is a precaution. Conduct all these experiments as quickly as possible if in the evening, because the discharges will interfere with radio reception.

With this Tesla transformer one may conduct an endless number of experiments which are too numerous to mention here and it will be well to look up some information on high frequency currents before actually doing any experiments or else one may not know the meaning of it all.

This simple apparatus should prove a delight to one's friends who are interested in experimental work and if several persons become engaged in the research some very fine results will be deduced. The field of high frequency currents is a broad one and to the "radio fiend" they will be a boon because they will enable him to more clearly visualize the actual mediums in existence, as we may express it, and thus enable one to become more thoroughly familiar with the "greatest indoor sport" of the time.

While the transformer is in actual conversion of the low potential to high potential it is well to be extremely cautious in all the adjusting because the low frequency current with such a high voltage stored up in the condenser is liable to cause injury if you

This connection is similar to the one above but a spark coil system is used for the supply. Again we find a horn gap, choke coil and condenser. In both these connections the condenser is in parallel with the coil.




experiment is to test the insulation of a so-called safety screw-driver used by electricians. Note the results.

The discharges may be taken by the person performing these experiments employing a metallic rod to draw them off. This is not a painful practice. In fact, the actual discharge on to one's finger tips is rather exhilarating. These high frequency currents

happen to receive an electrical shock. Constant caution will well repay and is to be preferred to saying it with flowers.

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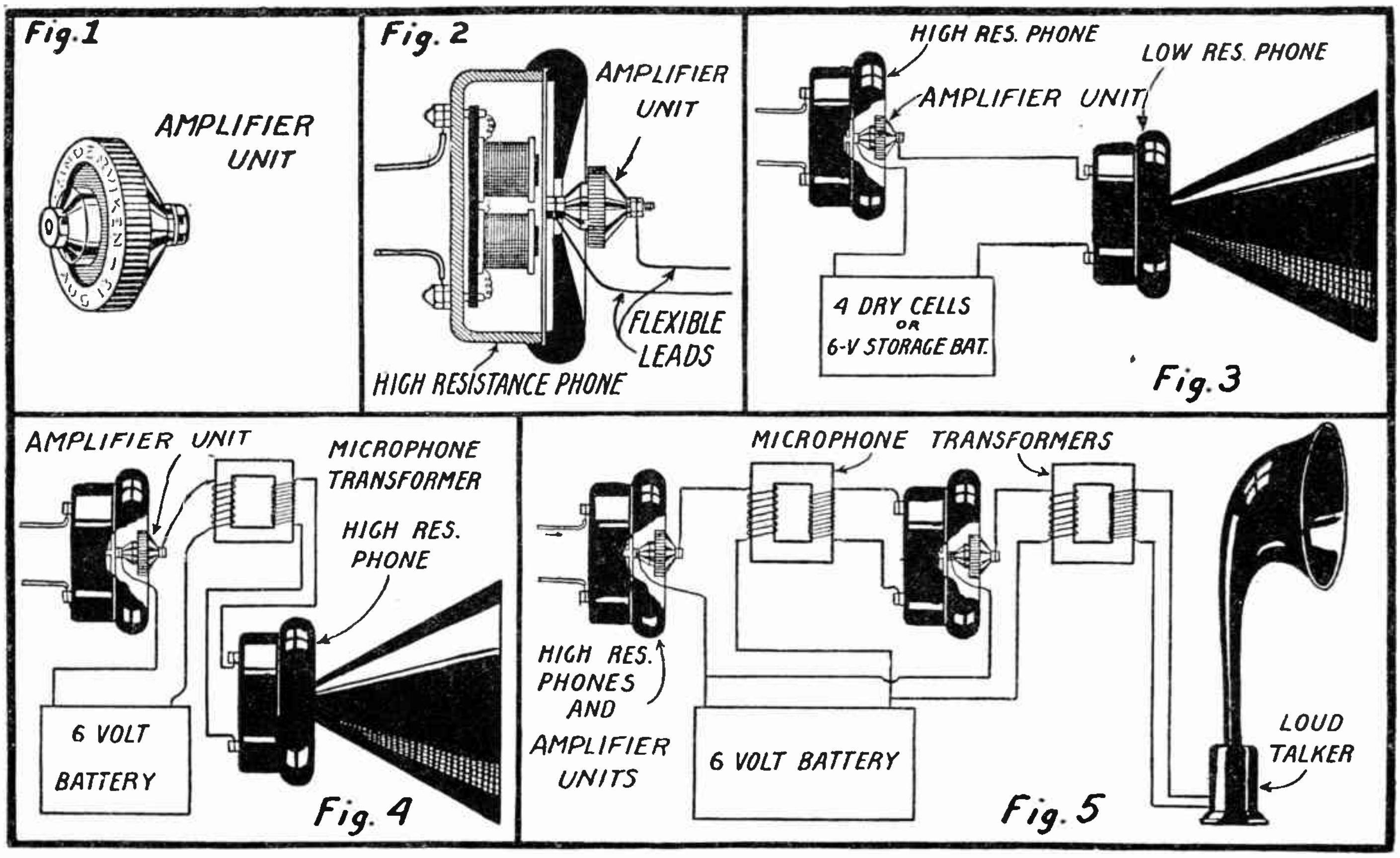


FIG. 1 shows the amplifier unit, actual size.

FIG. 2 shows how the unit is attached to a telephone receiver. The first procedure is to mount the unit on the diaphragm of a telephone receiver, which usually is a high resistance telephone, either 1,000 or 1,500 ohms.

Next we select the loud speaking telephone. If a low resistance telephone is available, it should have for maximum efficiency an impedance equal to the resistance of the amplifier unit, or about 10 ohms; it is connected up as shown in Figure 3. A 5 ohm telephone receiver is used in this circuit with a 6-volt storage battery.

Two telephones taken from a good double head-set of 2,000 to 3,000 ohms which do not rattle on strong currents, are employed in Fig. 4, one at the receiving end, the other as loud talker. In this hook-up there is one instrument which must absolutely be used with this combination, the transformer. As stated before in connection with Fig. 3, the impedance of the telephone, if used in direct connection, should equal the resistance of the unit. But as the impedance of the telephone in Fig. 4 is much higher than the resistance of the unit, it may be 200 times as great, a transformer having a step-up ratio is used to match up the resistance of the unit with the impedance of the loud speaking telephone. In other words, the primary coil of the transformer should have an impedance (which is sometimes called "A. C. resistance") equal to the resistance of the unit, or about 10 ohms, and the secondary coil should have an impedance equal to the impedance of the high resistance telephone. This transformer may be purchased in any Radio Store and is called a microphone transformer or modulation transformer, designed primarily to use in radio transmitting sets. A 6-volt battery gives the best results. The current passing through the unit will vary from .1 to .25 ampere.

FIG. 5 shows a circuit for further increasing the volume of sound. This is simply two of the circuits, such as shown in Fig. 4, linked together. This arrangement is highly sensitive and the telephones on which the units are mounted should be packed in a box of cotton, as the slightest vibration or sound in the room will be picked up and heard in the loud talker. Any sensitive radio loud talker may be used in this particular circuit.

These and innumerable other interesting experiments are possible with these amplifiers. Every amateur should have at least one or two in his "Lab" or workshop. A four-page instruction pamphlet is sent with every unit.

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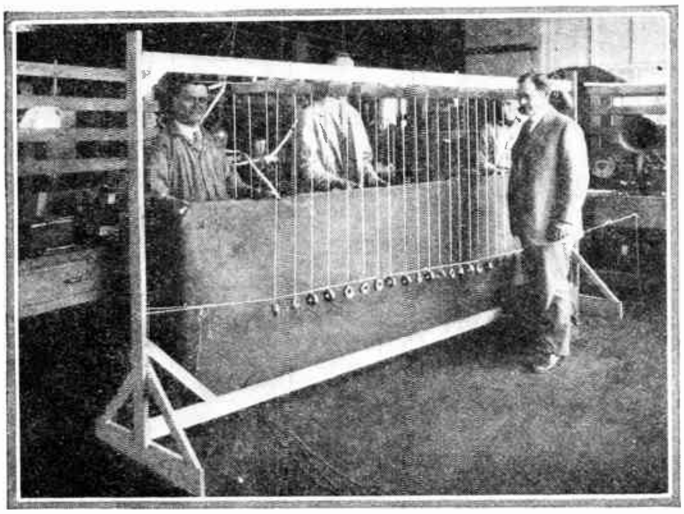
# Polarization of Radio Waves

(Continued from page 247)



The mechanical model consists of 22 weights arranged in a row and connected together by rubber bands. Each weight is suspended from a yoke and an equal weight is hung from the other side as a counterbalance. A shield is used so as to avoid confusion in observing the wave motion.

of the first weight is passed along as an elliptical motion which gradually widens into a circle. Then this circle narrows down again to an ellipse and finally to a straight line at right angles to the original line of oscillation. This is exactly in accordance with the theory. The point where the wave has shifted its plane of polarization 90 degrees is the point where the faster of the two waves is half a wave-length ahead of the slower wave. From this point on, the wave proceeds, repeating this peculiar corkscrew motion.

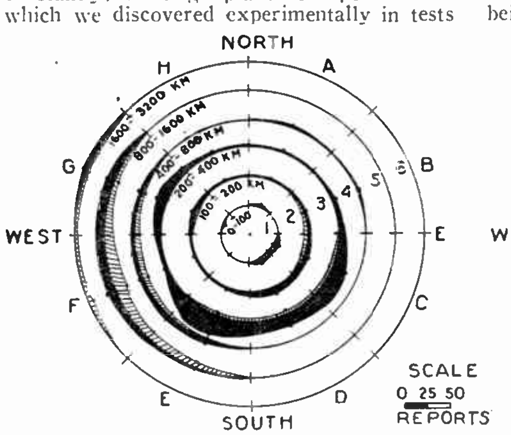
The fact that the twisting of the wave is due to different velocities in the two planes of polarization can also be demonstrated by this model. For this purpose, the rubber bands are added to the counter-weights. The effect of this is to change the velocity of propagation in the vertical plane, whereas, the velocity in the horizontal plane has not been affected, because only the vertical motion is transmitted to the counter-weights by the suspension yokes. The system can thus be adjusted so that the velocities in the horizontal and the vertical planes are exactly equal. After this has been done, it is found that the tendency to corkscrew-motion disappears and the wave remains strictly in the plane in which it has been started.

While this mechanical experiment does not bring out any facts that were not known from the classical theory of wave motion, it helps us to visualize the main phenomena in the radio wave propagation which we are trying to explain. The phenomenon of a constantly shifting plane of polarization which we discovered experimentally in tests between Schenectady and Long Island can thus easily be explained.

This conception of the wave motion is also a help in explaining the phenomenon of fading. There is already much experimental evidence that fading is a phenomenon of interference. In other words, the fading is due to the fact that the radio waves arrive at a certain point through two paths. The waves will sometimes be additive, with respect to each other, and will sometimes neutralize each other. If we keep in mind the observations on the mechanical model, that the waves in the two planes can be traced through separately and distinctly, we may conclude that the two paths of the radio wave, which produce fading, are not necessarily two separate physical paths, but may be the two paths in the horizontal and the vertical planes of polarization. For further illustration of this, we can, in the mechanical model, introduce a detector.

If we place this detector at a certain distance from the original, we find that the detector gives no response when the system is adjusted for different velocities of propagation, whereas, it gives a maximum response when the system is adjusted for equal velocity in the horizontal and vertical plane. The phenomena of fading has thus been reproduced mechanically through polarization in a single wave path.

It is not hereby suggested that this mechanical equivalent is sufficient to explain the fading in actual radio transmission. It is, however, offered for what it may be worth as a help for interpreting the many observations in actual radio transmission which are being accumulated.

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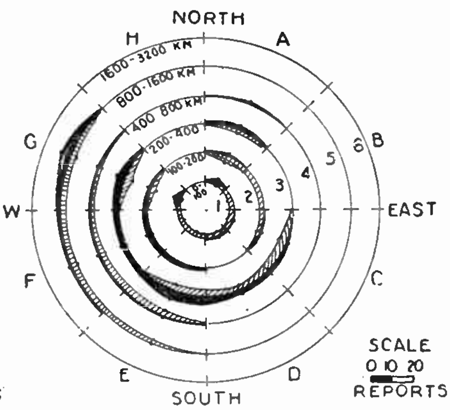
HORIZONTAL LOUDER
VERTICAL LOUDER

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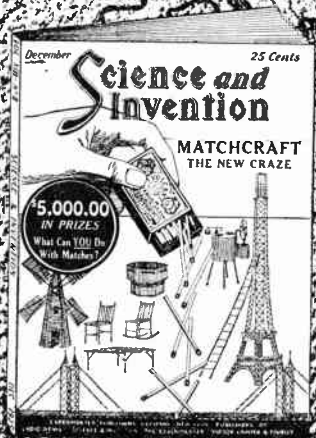


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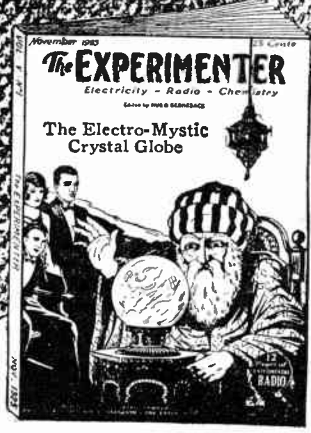


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